20TH ANNUAL Mancini Science Symposium

May 8th, 2014
Volume III
Foreword

Paradise Valley Community College is proud to present this 3-volume set of the 20th Annual Mancini Science Symposium. This symposium was held on May 8, 2014 in the Kranitz Student Center (KSC) Community Room.

Students enrolled in Astronomy, Chemistry, and Physics classes from PVCC participated in the event. Each contributor was responsible for selecting and researching his/her topic and preparing a paper. This 3-volume set contains all the research papers. A few students gave oral presentations of their project to their peers. The topics that were presented in this symposium were chosen by the students themselves via a voting process.

As instructors and faculty advisors for this symposium, we want to thank and congratulate each participant for his/her effort, courage, and dedication. By participating, these individuals perpetuate this event annually. We are proud and honored to present the work of these individuals.

Casey Durandet, PhD
Scott Massey, PhD
Jennifer Weitz, MS
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World Creation Myths of Earth and Sky: The Precursor to Astronomy

Matthew Pulido
AST111
April 12, 2014
Professor Jenny Weitz
Before science was developed as a method to understand the universe, ancient cultures used myths containing gods and mythical energies to try and explain the mystery of life and how everything came to being. From the glory days of ancient Rome, Egypt, Greece and China to the spiritual beliefs of the Mesoamerican and African tribes, there is always an interpretation of the origins of our universe. Despite the different perspectives of each culture or religious belief, there are similarities as to how the universe first started out. In the following paragraphs below you will see detailed creation myths of our universe and planet from some of the most influential cultures in our history.

In scientific terms the universe was really created by an event called The Big Bang. However, we should remember that in the ancient past, our ancestors did not yet have the benefit of science in order to give an explanation as to how everything was created. For the most part, creation myths start out with the universe being empty and chaotic and then creation happening due to the power of some omnipresent god(s) or by a mystical energy that was responsible for having shaped our universe in the first place. The most well-known creation myths have their connections to religion. The Christian faith as stated in the Bible believe that, “In the beginning God created the Heavens and the Earth”.

The story goes to say that “God created light, the sun, moon, the stars, animals and the first two humans Adam and Eve. Through temptation by a snake, Eve ate one of the forbidden fruit that God made her and Adam Promise not to eat. Afterward Eve connived Adam to also eat the fruit God became furious for disobeying him and as a result banished Adam, Eve and the snake from the Garden of Eden forever”. (Source 1). Even in today’s world, Christians believe in this concept on how our universe was born and how everything else happened afterward. David Christian, the author of Origins of Universe describes this concept as being used by the
Egyptian astronomer Ptolemy in his cosmological models detailing the creation of our universe (Source 2).

The oldest creation myth (historically speaking) that we will cover first comes from ancient Babylonia. Their account on the creation of the universe is that, “There was Apsu the great water sea and Tiamat, the salt water sea. When they came together they created the gods Lamu and Lahamu, who in turn created the other gods. From the gods rose Ea and his brothers, who were very restless and rambunctious. This cause great unrest in Apsu and Tiamat who asked Ea to move around more softly, but Ea didn’t hear them. Apsu decided to destroy Ea in order to end his rough-housing. Ea, however found out and killed Apsu. Tiamat in retaliation created an army of monsters to kills Ea, but Ea and the other gods created the sun god Marduk to counter this threat. In exchange for making Marduk ruler of the cosmos, Marduk agreed to kill Tiamat. Marduk succeeded in doing so and sent half of her body into the heavens to form the sky and the other half to form the earth. Marduk also created the days of the year, the planets, the stars, constellations and the moon, including its phases” (Source 1). The book “World Eras”, in its tenth chapter talks about how in Babylonian astronomy the universe was depicted as having a six levels with three heavens, three different “earths” and one underworld for the dead (Source 3).

Far to the east, the people of ancient China, believed that “The universe first started out as an enormous egg containing chaos. Within it, the chaos raged as Yin and Yang were mixed together. The opposites were writhing together; male and female, hot and cold, wet and dry, dark and light. Finally the egg burst open and from it emerged the giant dragon Pan-gu. Thus the opposites were separated and the world began to take shape. Every day for 18,000 Pan-gu grew ten feet. As a result the sky was raised farther and farther for the Earth. Once the sky was 30,000 feet above the ground, Pan-gu created the mountains and filled the valleys with water to form the
oceans. He created rivers with his fingers and tossed raw light into the skies, which became the stars. After he had finished creating the world and the basic principles of Yin and Yang, Pan-gu was old and tired. He then laid to sleep for the rest of his life. After his death Pan-gu’s body became huge mountains, his skull formed the top of the sky, his hair became plants and flowers, his bones became jade and pearl, his arms and legs became north, south, east and west and his eyes became the sun and the moon” (Source 1). The story was reviewed by John Harding in the World History Encyclopedia stating, “This creation myth includes themes and images found elsewhere in Chinese literature and beyond China. Creation from the dismemberment of a giant being is similar to the sacrifice of the cosmic man, Purusha, found in earlier Vedic literature. Moreover, the origin of the sun and moon in Pan-gu’s myth recur in the later Japanese creation myths where Izanagi gives birth to the sun and moon from his left and right eyes respectively” (Source 4).

From China, we now head over to Japan where they have a creation myth that bears some similarities and differences from their Chinese neighbors. They believed that, “Before there was heaven and earth there was darkness. In the midst of this darkness was a swirling mass in the shape of an enormous egg that contained everything. Over the course of many years the lighter and purer part drew away from the heavier and denser part. The heavier part of became known as Yin and the lighter part became the heavens, which became known as Yang. One couldn’t exist without the other and everything was comprised of either one of these two forces. From this separation the first being appeared; Izanagi (male who invites) and Izanami (female who invites). Izanagi thrust a jewel-tipped spear into the darkness and created the Earth so that he and Izanami could live on it” (Source 1).
In ancient Greece, it was said that the creation of the universe was credited to Gaia the earth goddess and Uranus the sky god and who were born from chaos itself. Uranus was soon other thrown by his son Kronos the Titan and took his father’s place as ruler of the heavens. However Kronos became fearful of his own children overthrowing him and so devoured them all whole. In secret Gaia and Kronos’ wife Rea hid away his youngest child Zeus and in time Zeus freed his other siblings and destroyed Kronos. Afterwards Zeus created Olympus and with the other gods ruled over the universe (Source 1). Whenever the Greeks looked up into the night sky they would name astrological objects like planets and constellations after many different gods, heroes, and creatures from their many different myths as a sign of respect to their creators. Examples of this practice are the planets Venus, Uranus, Neptune and Jupiter. Others include the constellations Hercules, Orion and Pegasus.

Across the sea to the valley of Mexico, we come to the ancient civilization of the Aztecs. Their idea to how the universe was formed is stated that, “Before the earth had form there was Coatlicue the earth mother. It was her that created the moon and the stars, the first of her children. Among them was her daughter named Coyolxauhqui, the earth goddess. While her children ruled the heavens and sky, Coatlicue found a ball of humming bird feathers and placed them in her dress for safekeeping. Soon she realized she was pregnant due to the humming bird feathers she placed in her dress. This angered her other children, who demanded to know who impregnated her. Coatlicue said it was a ball of humming bird feathers, but her children did not believe her and with Coyolxauhqui they decided to kill their mother for the shame she brought upon them. As she fled from them, Coatlicue heard the voice of her unborn child saying ‘Do not be afraid. I am ready’. She then gave birth the sun god Huitzilopochtli, who was fully armed, wield the flaming sword Xiuhcoatl. He then slew his angry sister Coyolxauhqui and cast the
upper half of her body into the heavens and sent her lower half to become the Earth. Huitzilopochtli then went on to rule over the moon and stars” (Source 1).

As with Greeks and Aztecs, the Egyptians had a multitude of gods with whom they connected to the great mysteries beyond our atmosphere. In Egyptians point of view, “There was Nu the dark swirling chaos before the beginning of time. From it rose Atum, who created himself through his own thoughts and sheer force of will. From his own body he gave birth to Shu, god of air and Tefnut, goddess of mist and moisture. Together Shu and Tefnut separated chaos into light and dark, creating order and stability. They soon created Geb the earth and Nut the Sky” (Source 1). As explained by El-Sayed el-Aswad, author of Creation Myth: Cosmogony and Cosmology, “The Egyptian god Atum creates the world from his own substance through his own body” which coincides with how the myth goes (Source 5). However, when it comes to astrological objects in Egyptian mythology, the sun god Ra is the most well-known and central entity in their religious pantheon. His influence was so great that he was associated with the pharaohs, giving him credibility as the symbolic leader of Egypt’s culture, as stated in the UXL Encyclopedia of World Mythology(Source 6).Ra’s appearance in hieroglyphics was depicted as having the head of a falcon with a shining solar disk on his head. Because the sun is our primary source of light and warmth on our planet, Sun gods throughout history in every kind of culture was held with high regard and was referred to with the utmost respect.

Another sun god to have as much notoriety and influence as Ra, was the Aztec god Huitzilopochtli (as previously referenced). It was said that Huitzilopochtli needed human blood for nourishment so that he could be able to make the sun rise the next day. To achieve this the Aztecs offered Huitzilopochtli a human sacrifice to give him the energy he needed to raise the sun. For the ancient Greeks, their Sun god was known as Apollo. It was said that like all other
Greek gods, Apollo was capable of being omnipotent, powerful and was especially respected for his connection to the sun.

Now I know that you may think that this is more historically based than that of Astronomy. That this is more fiction than fact and that these people weren’t smart enough to realize that wasn’t how it happened. However, even though these are all myths, they each contain a grain of truth as to how our earth and universe itself came into existence. What science has revealed to us had already found its roots in mythology and became the building blocks to what evolved in to our modern day astronomy.
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Aurora Borealis or Northern Lights

Lee Rank
20 March 2014
AST 111 16048
Professor Jenny Weitz
I will be explaining about the Aurora Borealis or the northern lights. Some of the stuff I will be discussing about the history, where you can find them, and other stuff. By the time we get to the conclusion you will know everything you need to know about the Aurora Borealis lights and have a better knowledge about them. The auroras are very amusing if you get a chance to see them. The lights are very rare because they only come at a certain time of the year.

According to some people the lights were originally discovered in 700 A.D. not when people claim it was found. Sometime in the 17th century there was a guy named Pierre Gassendi and he was the first person to give the lights their official name the Aurora Borealis. An interesting fact about Pierre is that he changed his last name because he was ashamed of his family because they were peasant’s farmers. He also had received a better education then most of his family and other
people. He also had a strong belief in Galileo. He named the lights after the Greek God of Aurora and that is how they got their name. No one exactly knows who the founder of the Auroras Borealis is. The Borealis name came from the Greek God of Borealis. According to Bones, he said the Aurora lights might have been discovered a thousand years back. Some people claim they also hear noises when the lights came flying in. According to the history books we don’t know when the lights were officially founded. As early as 2620 BC was the first time the lights might have been recorded.

Next aspect we are going to look at the northern lights is where you can find them in the sky. Alaska is one of the most common places in the United States to find the northern lights, they are very pretty. A tourist also can see the Aurora Borealis in Canada and some parts of Europe. There are only certain spots where you can capture the lights quick enough if you blink you might just miss them. Most people make this one of their many items on their bucket lists. The lights come up around from 6PM to 4AM it just depending on where you are living. The lights are mainly in places where it is very dark not getting a lot of light. If you have the time go and make a trip to one of the places you can see the God’s beauty in the lights. The lights are seen almost every place in the world but you have to be a night owl to see the lights or move to somewhere you can see them. A fact that most people do not is that there is a thing as the southern lights. The southern lights can be seen all the way in Australia. The lights are on my checklist to do before I die. Make sure when you go see the lights make sure the night is very
clear and not a cloud in the sky. Norway is one of the best places to see the lights most of the year because the weather is really good for the most part except the winter. When you go see the northern lights, they are mainly green most of the time and when a person wants to see the southern lights they will be red. People try to photograph the lights but they are one of the hardest things to get a picture because they are always moving. If you are one of the lucky ones to capture the lights put on a time lapse so people can see the lights when they start and go all the way to the finish. Travelers all around the world just come to the lights and they will make a great memory for the kids and grandkids. I really wish I could see the lights all the way in Arizona because then I would not have to go anywhere except maybe outside. There are more factors into the lights then an average person thinks. Everyone who is interested in science should really consider going to see the lights. The color happens when nitrogen and oxygen mix together and sometimes helium becomes a factor in the color of the lights. There are some side effects to the lights like radio static and other effects. Auroras have been a source of wonder for thousands of years. Images of auroras have even been seen in ancient cave paintings in France. The best chance to see the northern lights occur between the months of March through April and September through October, or anytime there is a solar storm. The solar storms are one big cause of the lights and an interesting fact is they think found some lights on other planets. Pictures may say one thousand words but I think seeing the lights are priceless. If you do not remember anything from this paper just remember to keep mother earth clean and less polluted and maybe we can change the
word so maybe other places can see the lights. I thought I had a lot of prior knowledge on the lights but after doing research I have found out more. I guess the moral of this essay you can never learn too much about a certain topic. I hope you have learned a thing or two about the lights. Thank you for reading my paper. I hope this taught you something more than how long and you have reading this paper. In the slide show you will learn more of stuff you likely did not know.
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A Brief Review of the Internal-Combustion Engine

Scott Ratcliff

November 18, 2013

Physics 112

Dr. Casey Durandet
Introduction

The modern internal combustion engine is a complicated, precision-built machine. When broken down to the most basic concept it converts linear force to rotational force. A force such as this can be used to drive various components that range from electric generators, automotive transmissions, fluid or air pumps and more. The variety is not just limited to what the machine can do, but extends to how it’s accomplished as well. The following paper will explore a brief history of the development of the internal combustion engine, individual components, types of cycles, and ignition systems.

Conversion of forces: The crankshaft and connecting rod

A crank can roughly be described as an arm attached to a shaft at any point offset from the center, hence the name “crankshaft”. Likewise, a connecting rod is simply a rod connected, on one end, to the crank and capable of moving only on a fixed linear path.

When the crankshaft spins, the offset arm imparts linear force on the connecting rod as seen in figure 1 below (Young, 2000). The connecting rod is also capable of the reverse.

It’s this conversion of linear to rotational force and vice versa that makes the engine such a useful machine.

It may be difficult to believe but this technology has been dated to around A.D. 370-390 (Ritti, 2007) where it was used in water-driven stone saw-mills.

It would be many years until the combustion engine became a possibility. It wasn’t until 1678 that Christiaan Huygens designed and built a gunpowder-fired engine for raising water (Geissbuhler et al, 2000). His crude machine wasn’t much more than a vertical cannon, firing a piston upwards with a rope attached to the end. The rope was run through a series of pulleys and attached to container that would fill with water when the piston was at its highest point. While Huygens’ engine didn’t take advantage of a crank, it’s historically significant as it is considered to be the first engine to take advantage of combustion (Geissbuhler et al, 2000). Unfortunately materials available at the time were not reliable or strong enough to make his machine practical.

Over roughly the next two hundred years, many inventors would make considerable contributions that played a role in the development of the internal combustion engine.

Alessandro Volta created a hand held device circa 1776, known as the Voltaic Pistol. While the name implies a weapon, in reality it measured force by igniting various flammable gases with an electric spark within a sealed chamber (Boebinger, 2013). The exploding gases acted upon a piston, forcing it outward where its distance traveled could be measured.
In 1799 Phillippe Lebon filed a patent for the process of extracting flammable gas from coal. A mere two years later in 1801 he filed another patent for an engine fueled by coal gas that would be ignited with an electric spark.

A span of almost fifty years would pass before Alphonse Beau de Rochas would submit the patent for design of the four-stroke engine. Though he never built his engine, he recognized the validity of compressing the mixed air/fuel before combustion (Geissbuhler, 2000). Finally, in 1876 Nicolaus Otto built the first gas-engine practical enough to replace the steam-engine. In fact, it worked so well Otto sold over 30,000 units over the next ten years (invent.org, 2012). It would be this machine that served as the basis of all modern internal combustion engines.

Phases of operation:

The Otto engine has four phases of operation, hence the name “four-stroke”. They are intake, compression, combustion and exhaust. Modern materials and machining may have made the Otto engine more efficient and reliable however, the mode of operation remains the same today as it was nearly 140 years ago.

The rotational point at which the crankshaft has moved the connecting rod and piston furthest away from its axis is called “Top Dead Center”, or TDC (Duffy, 1998). This marks the beginning of phase 1.

1. Intake: The crankshaft rotates past TDC, beginning a downward stroke of the connecting rod, pulling the piston away from the top of the cylinder. This creates a vacuum which draws air in, past a valve which opened at the beginning of the stroke. Fuel can either be mixed with air as it is drawn in or injected directly into the cylinder. If injected, the swirling movement of air distributes the atomized fuel. As the crankshaft continues to turn it reaches the point where it has drawn the piston closest to its axis of rotation. This is known as “Bottom Dead Center” or BDC and marks the beginning of phase 2 (Duffy, 1998).

2. Compression: The crankshaft passes BDC and the intake valve closes, sealing the cylinder. The upstroke of the piston compresses the air/fuel mixture increasing both thermal and mechanical efficiency (Aina et al, 2012). At a point (varies by RPM of engine) before the piston reaches the top of its stroke the ignition system causes a spark to arc across an air gap between the electrodes of a spark plug, starting the combustion phase (Duffy, 1998).

3. Combustion: The spark ignites the air/fuel mixture resulting in rapid expansion of gases and the release of heat. Because the cylinder is sealed the expanding gases push the piston down with extreme force. It’s this downward linear force that applies torque, via connecting rod and crank arm, to the crankshaft, allowing it to drive external components attached via gears, pulleys, belts…etc. The piston reached BDC once again and moves into the exhaust phase (Duffy, 1998).

4. Exhaust: At BDC the exhaust valve opens and the upstroke of the piston pushes the spent air/fuel mixture out of the cylinder. It reaches TDC, the exhaust valve closes, the intake valve opens and the cycle repeats (Duffy, 1998).
The Clerk Two-Stroke Engine

In 1878 Dugald Clerk patented the two-stroke engine in an effort to make a more compact, quieter petrol fueled engine (Royal Society, 1933). The basic premise combined the intake and compression phases into one stroke and the combustion and exhaust phases into a second stroke (Duffy, 1998). This type of engine requires a certain ratio of oil to be mixed with the fuel in order to provide lubrication. Figure 3, below, illustrates the combined phases.

1. Intake and compression: Upward motion of the piston creates a vacuum behind it, opening a reed valve which operates like a flap. This would draw the air/fuel/oil mixture into the crankcase. The atomized mixture is able to deposit enough oil on the engine surfaces to maintain proper lubrication (Duffy, 1998). Simultaneously, the upstroke creates compression in the cylinder to prepare for combustion.

2. Combustion and exhaust: A spark ignites the compressed fuel pushing the piston away. The reverse movement of the piston creates pressure in the crankcase, forcing the reed valve to shut. As the piston moves down the cylinder wall an opening is uncovered for spent gases to escape. Further movement of the piston exposes the “transfer orifice” while pressure in crankcase forces fresh air/fuel/oil into the cylinder (Duffy, 1998). The cycle repeats as the crankshaft continues around, causing the piston to close the “transfer orifice” and exhaust port.
Clerk was certainly able to accomplish his goal of making a smaller, quieter machine. He managed this by eliminating the complex timing mechanisms used to open and close valves. The noise level was reduced because gases were exhausted by the comparatively low pressure produced from combustion. Unfortunately it was also highly unreliable due to materials of that era. It wasn’t until the German company DKW invested in Clerk-cycle engines that they became a viable option (Geissbuhler, 2000).

Comparing modern two and four-stroke engines

Modern technology has seen vast improvements in the efficiency and output power of both two and four-stroke engines. The two-stroke is more compact and considerably cheaper to build because it has fewer moving parts. Most modern applications of the two-stroke are for small equipment such as trimmers, leaf blowers, lawn mowers and even motorsports where weight is critical. However, these engines are inherently dirty. Since the intake and exhaust phases occur simultaneously, a portion of unburned fuel escapes with the exhaust fumes. They also burn oil either by injection into the fuel or premixed in the gas tank. According to Carol Potera (2004), this produces drastically higher emissions of particulate matter, hydrocarbons and carbon dioxide than a “gas only” engine. Some countries with particularly high numbers of vehicles operating on two-stroke engines are even offering fiscal bonuses for owners who replace their machines with four-stroke operated ones (Potera, 2004).

The four-stroke engine on the other hand, has many more complicated components, generally making it larger and heavier. There are vast advantages though, in having a dedicated stroke for each phase of operation. This translates to each stroke maximizing work performed at each phase. The intake phase will not lose fuel during the exhaust phase as it would in a two-stroke. The combustion phase will be able to use a greater percentage of thermal efficiency as it is able to reach BDC before the exhaust valve opens (Duffy, 1998). Finally, as technology progresses these engines are rapidly becoming smaller and lighter weight. Many manufacturers are now even producing lawn equipment powered by small four-stroke machines.

The ignition of fuel

To this point, the engines discussed have either flame ignition or spark ignition sources. While flame ignition quickly gave way to electricity in the late 1800’s, a third ignition source was also being developed at the same time. In 1893 Rudolf Diesel presented an engine that used compression to ignite its fuel (Invent.org, 2012). His engine used a complicated set of additional machinery to inject air/fuel into the cylinder after the compression stroke. The compressed air
was so highly compressed at a ratio of roughly 16:1 that the heat of compression instantly ignited the fuel (Geissbuhler, 2000). His idea was slow to come to fruition however; in 1896 he presented another model that was capable of achieving over 75% mechanical efficiency. The most efficient steam engines at the time were performing at roughly 10% efficiency (Invent.org, 2012). It did not take long before he went into production and his engines saw use in every aspect of industry.


Young J. Elec 201 [Internet]. Houston, TX: Rice University; c1998 [updated 2000; cited 2013 Nov 1]. Available from: https://www.clear.rice.edu/elec201/Book/basic_mech.html#SECTION009340000000000000000
An Overview of the Foundation of Navigation

Megan Reder

04/01/2014

AST111

Professor Jenny Weitz
Abstract: The purpose of this paper is to overview how civilizations navigated before the use of maps. This paper will define what celestial navigation is and the process of using the sky to navigate. It will introduce the various instruments that navigators used and describe their impact on the development of celestial navigation.

Since the beginning of time, animals on planet earth have needed to navigate around in order to survive. Each species, being as unique as the next one have learned to navigate around in their own way. Human beings are considered to be the smartest species by innovating new ways to find their way around and reaching higher limits as centuries have past.

As human beings began to grow and develop more intellectually, they began to notice their world around them. As they began to explore, they needed to keep track of their surroundings in order remember where they had gone and where they needed to go back to. They started to notice that just like they kept the same pattern with their life, so did the magnificent beings in the sky; such as the sun, the moon, and the stars. Ancient civilizations followed the movements of celestial bodies throughout the year and took note of what they had seen. One can see this account in the example of the Stonehenge in New Zealand. The henge is composed of 30 meter diameter stone circle that includes 24 pillars of concrete joined by lintels surrounded by six outer stones. The stones mark the rising and setting positions of the sun and moon at different times of the year. It also includes prominent stars and constellations (2005, pp. 1405a-1405a). This example shows that civilizations were taking a major interest in how the movement of these bodies were relating to their everyday life and they used this information to move forward into
the future. As they began to take note and follow more pattern the revolution of change in navigation lead to the pre-map navigation known as celestial navigation.

Before the discovery of the use of celestial bodies to travel, ships were likely to stay within view of the coastline to avoid getting lost, even if it made their destination unintended. If needed to get across the body of water, they would travel as far along the coast to the closest point to the island before crossing the sea in order to reduce the risk and time that they would not see land. (Warmflash). During the day, the sun moving across the sky gave them their east and west direction. After some time captains began to notice that the night sky held a pattern that could help them with direction as well.” At any one time of the year at any point on the globe, the sun and stars are found above the horizon at certain fixed “heights”. (Tyson). As the earth turns through its daily rotation from west to east, the celestial bodies will appear to rotate from east to west. At the same time, viewers at different points on earth will get different observations of the bodies in the sky but over the 24-hour period, will have seen the same scene (Clark, 1993, pp. 360-370). One star that an observer could find that would always lead them north was the star Polaris or also known as the North Star.

The North Star was simple to find if one knew what they were looking for. At the North Pole which is 90 degrees latitude, the North Star can be found at an altitude of 90 degrees. At the equator, which is 0 degrees latitude, the North Star can be found on the horizon at a 0 degree altitude. (2010). In retrospect then, the latitude of the observer on earth is the altitude of the North Star. With this being said, then the ship that was planning to sail out of sight of land would simply measure the altitude of Polaris at his starting position. To return back, one needed only to sail north or south, as appropriate, to bring Polaris to the altitude of the starting position and then turn left or right as was appropriate and keep Polaris at a constant angle. (Iland) If the Polaris
star was not visible such as covered in clouds or below the horizon, the sailors would switch to another star in the Ursa Minor or Achernar in the southern hemisphere (Clark, 1993, pp. 360-370). Since the planet earth was unpredictable with weather and unfortunate circumstances, finding the Polaris star to navigate was not always easy in the open sea. As civilizations began to grow and travel more, they began to develop tools in order to help them find the heavenly bodies they needed to follow.
At first they would use their fingers in order to measure the distance and angle of the stars to their starting position. Then they began to use tools in order to help determine the angle which were more like objects attached to string held from the navigator. The Arabs and the Phoenicians were one of the first civilizations that started to invent such tools that helped them navigate easier. One of the first devices was a sun-shadow disk that worked like a sundial that helped measure the length of the sun’s shadow on a disk that floated level in water (Tyson). The Arabs made a simple device called a Kamal. It was a wooden piece attached with a cord. Before leaving a port, the sailor would tie a knot in the cord so that when holding in his teeth he could sight Polaris along the top of the wooden object and the horizon on the bottom. (Ifland). Then they developed the Quadrant and the Astrolabe. The invention of the quadrant was huge step forward in the accuracy of measuring latitude. A navigator would mark the latitudes of his position on the instrument just as one would tie a knot in the string of a Kamal. The quadrant was divided into 90 degree intervals, and was held vertically in line of the celestial body. “The quadrant was a popular instrument with Portuguese explorers. Columbus would have marked the observed altitude of Polaris on his quadrant at selected ports of call just as the Arab seaman would tie a knot in the string of his Kamal” (Ifland). However, the quadrant was difficult to use because it had to be held vertically in the open sea full of moving water (2010). The Astrolabe was a lot more useful because it was able to hang freely as it captured the light of the sun or the star. It was a small disc
of metal that was suspended by a small ring held by the user. The alidade was adjusted so that the light passed through a hole in the upper vane and fell through the lower vane. The picture to the left is a navigator holding the astrolabe in position of where the celestial body is.

Another type of instrument was the cross-staff that was a T shaped device that was held to the eye. It would measure the sun's height by pulling the sliding top of the T towards one’s eye till the sun was at the top and the horizon at the bottom. However this often lead to blindness, so in 1595 John Davis invented the back staff that allowed one to measure the sun with their back facing the sun (Tyson). After some time of using this type of instrument, navigators began to notice that the device was splendid for using to determine the sun’s position however was difficult in order to use at night to determine the stars and moon. Thus began the development of optical systems using mirrors and prisms.

The most important and most achievable instrument was the sextant invented in the 1700’s. The central idea was to use two mirrors to make a reflecting device. The device was simpler to user and had less trouble with the disturbing variables with being in the open sea such as wind and moving of the ship. The holder would hold the instrument vertically and point it towards the celestial body in the sky. Then one would see the horizon through the portion of the horizon mirror. They would then adjust the arm until the image of the celestial body would reflect on the first mirror to the second mirror and thus appear to rest on the horizon. The altitude then could be read from the scale that was marked on the arc of the instrument's frame. (Ifland)
While the navigators were discovering more and more land by being able to determine their latitude, they were still crashing into shore because it was still impossible to determine the longitude. Navigators learned that they could determine the longitude using lunar distances. The moon was like a hand of a clock that was moving across the sky that was the clock face. They would use this technique to determine the angle position of the moon compared to the sun or other objects in the sky. If they knew the correct time they could then determine the longitude. Some issues of this was that it was difficult to determine the accurate time and it would take hours to work ones position. After the chronometer was invented, navigators were able to accurately determine the time and thus find the longitude.

As civilizations became more developed and the sextant became more advanced, navigation became easier and more available to use. As the sextant for determining latitude and the chronometer for longitude, navigators were able to navigate the high seas with amazing accuracy thus lead to the revolution of a new world. Cities began to grow and countries began to rise and spread. Navigation became more accurate as bright minds developed technology that would lead to precision map making and global position leaving no land undiscovered.
References


The Origins and Facts of the Solar System’s Jewel

Morgan Redmon

Professor Weitz

AST 111

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Saturn is not referred to as “the jewel of the solar system” for nothing. In Roman mythology, Saturn was the God of agriculture and the father of Jupiter, king of the Roman Gods. Among Greek mythology, it was the God Cronus, who was the son of Uranus and Gaia and the father of Zeus (Jupiter). It is even the root word for the weekday Saturday! Saturn’s fame has been observed going back to ancient times, the Babylonians, the Greeks, Romans, Hindus, and many other ancient civilizations who have worshipped and studied this beautiful ringed planet. When one gazes up at Saturn through a telescope in their backyard on a starry night, they are following the same actions as the famous astronomer Galileo Galilei, who was the first to take note of the planets rings in 1610. But back then, the telescope was not strong enough to take a good view of Saturn, and Galileo assumed that the rings were “handles,” or large moons, on either side of the planet. His theory is supported by observations from Esposito, Colwell, Burns, Hedman, and Porco, who suggest that the origins of other ringed planets like Jupiter, Uranus, and Neptune are the result of nearby moonlets surrounding them (though their rings are not visible by the viewer). But Saturn’s rings are the largest and the brightest of the four ring systems surrounding each of the giant Jovian planets.

Saturn’s rings’ structure looks like a gramophone record, a plate with a huge amount of circle channels with width in 100 m. This is called the “thin” structure of Saturn’s rings. The structure may be explained like phenomenon of formation of the periodic structure of the diamagnetic liquid film under influence with normal magnetic field (Tchernyi “Possible Electromagnetic). M.K. Dougherty’s Origin and Evolution of Saturn’s Ring System explains in detail the multiple physical processes of the rings. He explains that a “growing consensus” as to why Saturn’s rings are so prominent is because
“the ring particles are actually agglomerates of smaller elements that are at least temporarily stuck together: these temporary bodies are subject to both growth and fragmentation. The balance between these competing processes yields a distribution of particle sizes and velocities” (Dougherty). Saturn’s rings have the same mass as Jupiter, Uranus, and Neptune, and they contain the same phenomena, such as gaps with embedded moons and ringlets, narrow rings, broad rings, ethereal rings, waves, wakes and wiggles. But based on photographs taken from the Cassini-Huygens satellite, it is clear that the rings presently observed through a telescope are not created the same way. “Like the ring systems of the other giant planets, Saturn’s rings overlap with numerous small moons, including Pan and Daphnis. Not only do the nearby moons affect the rings dynamically, but they can also interchange material. These ‘ring moons’ thus provide a source of material for making the rings, and also possible sinks, affecting the size distributions of particles” (Dougherty).

Saturn’s rings are constructed of a main ring system, which consist of rings A, Cassini Division, B, and C that are below Saturn’s Roche limit for ice and are made of particles larger than ~1 cm across. They are bright and collisionally evolved, with optical depths ranging from ~0.1 (C Ring, Cassini Division) to more than 5 (B Ring). Collisions are a major driving process for the main rings. Due to their closeness to Saturn tidal effects are also strong. “The faint ring system includes the E and G Rings. They are mainly made of micrometer-sized dust. The E and G Rings are very faint and in general hardly visible from Earth. Due to their low densities, mutual collisions play almost no role in their evolution, although due to the small size of their constituent particles, non-gravitational forces (e.g., radiation pressure and Poynting-Robertson effects) are
important to their evolution. By contrast, non-gravitational forces are generally assumed to play almost no role in the main ring system. Tidal effects play only a minor role in the E and G Rings because they are located outside the Roche limit for ice” (Dougherty).

V.V Tchernyi suggests that the prominence of Saturn’s rings may be the result of magnetic activity. “Under the conditions of the continuous pump of energy by the rotating magnetic field of the planet into the rings particles flow, redistribution of particles resulting in an occurrence of periodic ring structure is possible” (Tchernyi). The theory of magnetic pull around the planet gives valid explanation to the amount of debris in its rings, such as “water ice” along with dust and other chemicals, which construct the rings’ prominence. “The speed of a magnetic field will coincide with the speed of particles, driven on Kepler orbits, only on the corotation radius and will be different from the speed of the particles at all other distance from [the] planet” (Tchernyi).

Aside from its rings, Saturn gains much of its fame from its largest moon, Titan which, with its thick atmosphere and organic-rich chemistry, is almost like the early version of Earth before it was filled with oxygen and inhabited with life. Saturn has multiple other moons; Tethys, Dione, Rhea, Iapetus (all discovered from 1671 to 16720, Mimas, Enceladus (discovered in 1789), and Hyperion (discovered in 1848). But Titan catches scientists’ attention because of its earth-like qualities; it has an active atmosphere and goes through many earth-like processes. The atmosphere is covered in natural gases like methane, so Cassini is unable to take good pictures of the surface, but this gas shows evidence that the moon goes through cycles like rain. Scientists also assume that volcanoes erupt in the moon’s surface, but with liquid water instead of lava. Cassini’s instruments have revealed that Titan also possesses many geographical parallels to Earth-
clouds, dunes, mountains, lakes, and rivers.

Although each special in their own ways, Saturn’s other moons are not as astronomically interesting as Titan. Iapetus has one side as bright as snow and one side as dark as black velvet, with a huge ridge running around most of its dark-side equator. Phoebe orbits the planet in a direction opposite that of Saturn’s larger moons, as do several of the recently discovered moons. Enceladus actually displays evidence of active ice volcanoes: Cassini observed warm fractures where evaporating ice evidently escapes and forms a huge cloud of water vapor over the south pole. Hyperion has an odd flattened shape and rotates chaotically, assumedly due to a recent collision. Pan orbits within the main rings and helps sweep materials out of a narrow space known as the Encke Gap. Tethys has a huge rift zone called Ithaca Chasma that runs nearly three-quarters of the way around the moon. Four moons orbit in stable places around Saturn called Lagrangian points. These places lie sixty degrees ahead of or behind a larger moon and in the same orbit. Telesto and Calypso occupy the two Lagrangian points of Tethys in its orbit; Helene and Polydeuces occupy the corresponding Lagrangian points of Dione. Sixteen of Saturn’s moons keep the same face towards the planet as they orbit. Called “tidal locking,” this is the same phenomenon that keeps Earth’s moon always facing toward Earth.

Whether it be its beautiful rings or its multiple moons, Saturn is a miraculous planet, even when gazing at it in the night sky through a telescope. Its rings contain debris, but do not think of it like litter in a parking lot. The debris is what makes it stand out among the other planets. It is not a wonder as to why this particular planet is referred to as “The Jewel of the Solar System.
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Electromagnetic Pulses (EMP)

Aaron Renfro
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Dr. Durandet
Abstract

Magnetic pulses can generate from multiple sources, whether it be natural like lightning or man-made such as electric motors, or even used as weaponry, pulses are made sending some kind of charge. But what happens when the charge becomes so large in magnitude over a brief period of time. What happens to our electrical equipment? Electromagnetic pulse is a short burst of energy that gives off a large amount of gamma rays that collide with air molecules knock electrons off in an event called Compton Scattering. Huge amounts of energy is given off in a short amount of time inducing current and voltage causing an overload in the electrical equipment, damaging anything within the radius of the pulse.

Electromagnetic Pulse

When EMP pulses comes to mind we think nuclear warfare or some type of mass explosion. Some of us who’s played Call of Duty or have seen the movie The Matrix might be familiar with EMP grenades. You throw one out and it creates an electric field so massive that it induces the current creating a much larger voltage shorting out any electrical equipment. What is an electromagnetic pulse? An electromagnetic pulse also known as, EMP, is a high intensity burst of electromagnetic energy caused by the rapid acceleration of charged particles. An EMP has the potential to decimate ALL of America’s technology, knocking out equipment, destroying grids and leaving America in the dark for days. EMP’s are not only caused by nuclear weapons; natural phenomena such as lightning strikes or solar radiation can give off flares creating electric pulses. Severe solar storm can also generate an EMP-like effect and shut down the electrical grid. In 1859, British astronomer Richard Carrington spotted large solar flare, and within minutes, electric pulses reached earth and affected the first the telegraph. Lightning is a massive electrostatic discharged formed in regions of clouds that has become charged and the Earth's surface. The charged regions within the atmosphere temporarily equalize themselves through a lightning flash.

EMP pluses were first introduced in the 1950s when electrical equipment failed because of induced currents and voltage during nuclear test. High energy electrons are produced in the environment of an explosion when gamma rays collide with air molecules, better known as the Compton Effect. Positive and negative charges in the atmosphere are separated as lighter charged electrons are swept away from the explosion point and the positively charged ionized air molecules are left behind. This charge separation produces a large electric field. Asymmetries in the electric field are caused by factors such as the variation in air density with altitude and the proximity of the explosion to Earth’s surface. These asymmetries result in time-varying electrical currents that produce the EMP. The characteristics of the EMP depend strongly on the height of the explosion above the surface. An EMP typically contains energy at frequencies from zero Hz to some upper limit depending on the source. The highest frequencies are generated by NEMP (nuclear electromagnetic pulse) bursts and continue up into the optical and ionizing ranges. Other types can leave a visible trail, such as lightning and sparks, but these are side effects of the current flow through the air and are not part of the EMP itself.
The waveform of a pulse describes how its amplitude changes over time. Real pulses tend to be quite complicated, so simplified models are often used. Such a model is typically shown either as a diagram or as a mathematical equation.

Most pulses have a very sharp leading edge, building up quickly to their maximum level. However pulses from a controlled switching circuit often take the form of a rectangular or "square" pulse. In a pulse train, such as from a digital clock circuit, the waveform is repeated at regular intervals. EMP events usually induce a corresponding signal in the equipment, due to coupling between the source and victim. Coupling usually occurs most strongly over a relatively narrow frequency band, leading to a characteristic damped sine wave signal in the victim. Visually it is shown as a high frequency sine wave growing and decaying within the longer-lived envelope of the double-exponential curve. A damped sinewave typically has much lower energy and a narrower frequency spread than the original pulse, due to the transfer characteristic of the coupling mode. In practice, EMP test equipment often injects these damped sinewaves directly rather than attempting to recreate the high-energy threat pulses.

Minor EMP events cause low levels of electrical interference which can affect the operation of susceptible devices. For example a common problem in the mid-twentieth century was the interference emitted by the ignition systems of gasoline engines, which caused radio sets to crackle and TV sets to show stripes on the screen. At a higher level, an EMP can induce a spark, for example when fuelling a gasoline engine vehicle, such sparks have been known to cause fuel-air explosions and precautions must be taken to prevent them. The direct effect of a very large EMP is to induce high currents and voltages damaging electrical equipment or disrupting its function giving quick burst of energy is call TEMP. A very large EMP event such as a lightning strike is also capable of damaging objects such as trees, buildings and aircraft directly, either through heating effects or the disruptive effects of the

![Diagram of EMP effects](image)
very large magnetic field generated by the current. An indirect effect can be electrical fires caused by the heating. Most engineered structures and systems require some form of protection against lightning to be designed in. These damaging effects have led to the introduction of EMP weapons. Measurements indicate that lightning strokes contain significant amounts of energy. Lightning creates electric fields in the discharge over a region of $10^6$ V/m, over an order of magnitude of $10^{12}$ W, and energy dissipation between $10^9$ and $10^{10}$ J. This is extreme amounts of heat and energy. Satellites have detected many lightning bolts with currents as high as $10^6$ A. A direct lightning strike produces the most severe effects. The high current density of $10^3$ A/cm² in a stroke delivers extreme power to the strike point resulting in demolished structures such as exploded timber, molten metal, and charred insulation. Lightning transients can propagate along transmission lines at almost the speed of light, in fact, a lightning strike on the 110-kV line of the Arkansas Power & Light Company reached a peak voltage of 5 million volts within 2 µsec without calamitous results. The primary effect of the TEMP is to induce overvoltage’s and overcurrent’s in the power system. These induced voltages and currents cannot cause flashover across transmission lines, and can only do so in isolated instances. The TEMP excites all three phases and the ground wire(s) similarly and almost simultaneously. Thus, it cannot produce large enough voltage differences between the lines to produce breakdown.

The switching action of an electrical circuit creates a sharp change in the flow of electricity. This sharp change is a form of EMP. Typically these send a pulse of voltage or current down any electrical connections present, as well as radiating a pulse of energy. The amplitude is usually small and the signal may be treated as interference. The switching off or "opening" of a circuit causes an abrupt change in the current flowing. This can in turn cause a large pulse in the electric field across the open contacts, causing damage. Electronic devices such as valves, transistors can also switch on and off very fast, causing similar issues. The instantaneous rays emitted in the reaction and those produced by neutrons are basically responsible for the process that give rise to EMP. The gamma rays interact with the air molecules and produce an ionized region surrounding the burst point. This region is referred to as the deposition region. The negatively charged electrons move outward faster than the heavier positively charged ions. The region closest to the burst point has a net positive charge and further away having a net negative charge, the separated charges produce an electric field which can obtain a maximum value in about $10^{-8}$ seconds. If the explosion were to occur in a perfect atmosphere (constant density) the gamma rays that were emitted would uniformly go out in all directions. The electric field would be radial and symmetric, with the same strength in all directions. There wouldn’t be any electromagnetic energy radiated from the ionized region. But since such a world does not exist, we experience a difference in air density, variations in water vapor that
interfere with the ionized region. In all circumstances there will be a net vertical electron current generated. The time-varying current results in the emission of short pulse of electromagnetic radiation which is strongest in direction perpendicular to the current. After reaching its maximum peak the electric field strength starts to decrease and become smaller in magnitude. In spite of the duration of the pulse it carries an unimaginable amount of energy. As the radiation travels away near the speed of light, it will be collected by metallic objects and other conductors. The energy of the radiation can be converted into an electric current and high voltages. Any electrical or electronic devices will most likely suffer severe damage. EMP radiation is somewhat similar to radio waves. Radio transmitters are design to produce electromagnetic waves of a particular frequency but the eaves in the EMP have a wide range of frequencies and amplitudes. The strength of a EMP electric fields can be a million times greater than an ordinary radio. The energy form an EMP received in such a short amount of time produces enough current to damage the equipment. An equal amount of energy spread over a long period of time would have no effect, but a EMP energy is so massive and delivered over a short period of time it cause a lot more damage. As oppose to a high altitude, if such a burst of energy were to occur at surface level the gamma rays the generally travel downward would be absorbed in the upper layers of the ground and essentially there would be no charge separation or electrical field in that direction. The rays moving outwards produced a ionization and charge separation in the air, resulting in a deposition region with ionized particles giving off an electromagnetic pulse. At the same time, the earth acts as a conductor allowing the electrons to flow back toward the burst point where the positive ions are concentrated. This produces a strong magnetic field along the ground. Although only about 3x10^-10 of the total explosion energy is radiated as EMP in a ground burst it is concentrated in a very short pulse. The charge separation persists for only a few tens of microseconds, making the emission power some 100 gigawatts. The field strengths for ground bursts are high only in the immediate vicinity of the explosion. High-altitude burst occur much differently than surface burst. The burst of electromagnetic radiation happens about 19 miles in the atmosphere the gamma rays moving in an upward direction will enter the atmosphere where the density of the air is so low that the rays travel a large distance before being absorbed. The gamma rays that are emitted downward will encounter a atmospheric region where the air density is constantly increasing. These rays will interact with the air molecules and form a deposition region for the EMP. This region can be up to 50 miles in diameter from the center with an altitude of about 25 to 35 miles. The electrons produce from the Compton Effect are deflected by the earth’s magnetic field. This motion causes radial acceleration in the electrons colliding with other
electrons, knocking them off the molecules in the air. The strength of the electric field observed at the surface from a high-altitude is from one-tenth to a hundredth within the source. However on the surface the radiation field drops off rapidly with distance. The electric field does not vary greatly over the surface or the atmosphere above the ground; instead the electric field is greatly influenced by Earth’s magnetic field.

The formation EMP begins with the very intense, but very short burst of gamma rays caused by the nuclear reactions in the bomb. About 0.3% of the bomb's energy is in this pulse, but it last for only 10 nanoseconds or so. These gamma rays collide with electrons in air molecules, and eject the electrons at high energies through a process called Compton scattering. These energetic electrons in turn knock other electrons loose, and create a cascade effect that produces some 30,000 electrons for every original gamma ray.

So what happens when the pulse hits the surface? As the pulse strikes the earth surface it can strike when a magnitude of a hundred amps per square yard. Electromagnetic pulses come as a wall of energy slamming any electrical components in its way. Of the two basic kinds of EMP, one is a relatively slow electro-magnetic pulse called magneto hydrodynamic EMP, similar to solar storms, lasting about 10 seconds inducing energy about 1 V/m.

EMP are not the only electromagnetic effect associated with a nuclear burst. Man-made radiation belts around Earth are also another occurrence. These belts interfere with communications by affecting them through which radio waves, and by direct interaction of the high-energy electrons. The belts produced by a nuclear burst cannot affect power grids, and are not part of what we call "the electromagnetic pulse."
Electromagnetic pulses are not just a man-made weapons used for havoc destruction there are also natural and civilian EMP

**Types of natural EMP event include:**

- Lightning electromagnetic pulse (LEMP). The discharge is typically an initial huge current flow, at least mega-amps, followed by a train of pulses of decreasing energy.
- Electrostatic discharge (ESD), as a result of two charged objects coming into close proximity or even contact.

**Types of (civilian) man-made EMP event include:**

- Electric motors can create pulses as the internal electrical contacts rotate.
- Gasoline engine ignition systems can create pulses as the spark plugs are energized.
- Continual switching actions of digital electronic circuitry.
- Power line surges. These can be up to several kilovolts, enough to damage electronic equipment that is insufficiently protected.

**Types of military EMP include:**

- Nuclear electromagnetic pulse (NEMP), as a result of a nuclear explosion. A variant of this is the high altitude nuclear EMP (HEMP), which produces a pulse of a much larger amplitude and different characteristics due to interactions with the Earth's magnetic field.
- Non-nuclear electromagnetic pulse (NNEMP) weapons.

**Electrostatic discharge** (ESD) is the sudden flow of electricity between two electrically charged objects caused by contact, an electrical short or breakdown. A buildup of static electricity can be caused by electrostatic induction. ESD occurs when differently-charged objects are brought close together, often creating a visible spark. ESD can create electric sparks like thunder and lightning, but also less dramatic forms which may be neither seen nor heard, yet still
be large enough to cause damage to sensitive electronic devices. Electric sparks require a field strength above about 4 kV/cm in air, as notably occurs in lightning strikes. Other forms of ESD include corona discharge from sharp electrodes and brush discharge from blunt electrodes. ESD can cause a range of harmful effects in industry, including gas, fuel vapor and coal dust explosions. These can suffer permanent damage when subjected to high voltages. Electronics manufacturers therefore establish electrostatic protective areas free of static, using measures to prevent charging such as avoiding highly charging materials, and measures to remove static such as grounding human workers, providing antistatic devices, and controlling humidity. ESD simulators may be used to test electronic devices, for example with a human body model or a charged device model.

The switching action of an electrical circuit creates a sharp change in the flow of electricity. This sharp change is a form of EMP.

The switching usually occurs in electric motors. Typically these send a pulse of voltage or current down any connections present, as well as creating a pulse of energy. The amplitude is usually small. The switching off or "opening" of a circuit causes an abrupt change in the current flowing. This can in turn cause a large pulse in the electric field across the open contacts, causing arcing and damage. Electronic devices such as valves and transistors can also switch on and off very fast, causing similar issues. One-off pulses may be caused by solid-state switches and other devices used only occasionally. By contrast the many millions of transistors in a modern computer may switch repeatedly at frequencies above 1 GHz, causing interference which appears to be continuous.

**Nuclear Electromagnetic Pulse** (NEMP) is the abrupt pulse of electromagnetic radiation resulting from a nuclear explosion. The constant change in the electric fields and magnetic fields produce damaging current and voltage surges. In military terminology, a nuclear warhead detonated hundreds of kilometers above the Earth's surface is known as a high-altitude electromagnetic pulse (HEMP) device. Typically the HEMP device produces the EMP as its primary damage mechanism. The nuclear device does this by producing gamma rays, which in turn are converted into EMP in the mid-stratosphere over a wide area. NEMP weapons are designed to maximize these effects, especially on electronic systems.

**Non-nuclear electromagnetic pulse** (NNEMP) is a generated electromagnetic pulse without use of nuclear technology. These devices have a large low-inductance capacitor bank discharged into a single-loop antenna, a microwave generator and an explosively pumped flux compression generator. wave-shaping circuits and microwave generators are added between the pulse source and the antenna. The range of NNEMP weapons is much less than nuclear EMP. Nearly all NNEMP devices used as weapons require chemical explosives as their initial energy source, producing only one millionth the energy of nuclear explosives of similar weight. The electromagnetic pulse from NNEMP weapons must come from within the weapon, while nuclear weapons generate EMP as a secondary effect. These limit the range of NNEMP weapons, but allow finer target discrimination. The effect of small e-bombs has proven to be sufficient for certain terrorist or military operations. Examples of such operations include the destruction of electronic control systems critical to the operation of many ground vehicles and aircraft. The concept of the explosively pumped flux compression generator for generating a non-nuclear electromagnetic pulse was conceived as early as 1951 by Andrei Sakharov in the Soviet
Union, but nations keep work on non-nuclear EMP classified until similar ideas emerge in other nations.

**Conclusion**

Although electromagnetic do not physical harm us, they can do catastrophic damage. EMPs can generate from numerous amounts objects. Lightning is a static discharge that creates EMPs that have been calculated up $10^6$ amps. EMPs also come from electrical discharge that omits major amounts of energy over a short period causing great damage to all of our electrical equipment. Becoming a society that is based on the necessity of technology the threat of a EMP would leave us in the dark.
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<http://www.empactamerica.org/>.

Abstract

This paper explores articles to help readers understand what shooting stars are, and how they are made. It will have a large number of information about shooting stars from different articles in order to get the most information about how they are formed, how fast they can travel, and how often they can be seen. The paper will include about how much meteoric material fall on Earth each day along with where they come from. The main topics will show how shooting stars can be categorized, their average speed, their size and weight, also with the amount that can fall during a given day and best ways to spot them.

Shooting Stars

Many of us have personally witnessed the natural space wonder called “shooting stars”, and many of us have also wondered just what exactly they are? Most assume at a young age that they are actual stars falling from the sky where we can close our eyes and make a wish but as we grow older our minds become more rational and start to thinking “just what exactly these shooting stars? “. Shooting stars make more sense to an astronomer than it would an average person, as they study the sky’s while most just stare at it. The information on shooting stars can be categorized in different sections to describe their different qualities such as:

1. What shooting stars are
2. The speed shooting stars can travel
3. The amount that fall per day
4. When can they be seen
5. Unique Characteristics
6. Scheduled days
7. Conclusion
What Shooting stars are

“Shooting stars are the streaks of light produced when a meteoroid burns up in the Earth's atmosphere” Delehanty, M. (2013). What many do not know is that shooting stars are not actually stars falling from the sky but dust and rocks in space. The two main sources of shooting stars are called comets and meteors, which can then break down into smaller pieces and appear as if one of the stars in the sky is falling. The way a meteor would resemble a star is “Once in the atmosphere, friction between the meteoroid and air molecules often produces the brief trail of light that we call a meteor.” Delehanty, M. (2013). Even though shooting stars can be categorized by particles traveling in fast speed with hot temperature, that doesn’t mean people should think too much different from them as they already do, meaning don’t let that take the magic away the next time you try to make a wish.

The speed shooting stars can travel

Shooting stars are usually seen close to Earth but “They are normally seen between 120 and 80km above Earth's surface.” Delehanty, M. (2013). The speed a meteor can travel is incredible as appears as flames will cover it because of its insane speed but “On average, meteors can speed through the atmosphere at about 30,000 mph (48,280 kph).” Formation, Facts and Discovery (2012). With such incredible speed its temperature is extremely hot and because of that “meteors can reach temperatures of about 3,000 degrees Fahrenheit (1,648 degrees Celsius). Sometimes, meteors can explode in magnificent fireballs that can sometimes be seen during the day.” Formation, Facts and Discovery (2012). Their speed can also be measured by their length and total size along with the weight. Since size will vary an interesting fact is “The largest individual iron is the Hoba meteorite from southwest Africa which has a mass of about 54,000 kg.” NASA/JLP (2014). The speed a shooting star travels do vary from falling stars since it
varies from its size and the amount of speed it can pick up. It is really fascinating how meteors can reach such density that it can explode small pieces of itself while traveling and that it is noticeable during daytime.

**The amount that fall per day**

There are many shooting stars that are spotted passing through Earth each day/night but just about how many falls per day? “Scientists estimate that 1,000 tons to more than 10,000 tons of meteoric material falls on the Earth each day.” NASA/JLP (2014). So what many might know be wondering is if there are so many particles that can potentially resemble a shooting stars, why do we not see as many? As scientist studied, they concluded with this statement “However, most of this material is very tiny - in the form of micrometeoroids or dust-like grains a few micrometers in size. (These particles are so tiny that the air resistance is enough to slow them sufficiently that they do not burn up, but rather fall gently to Earth.)” NASA/JLP (2014). Since people usually have a good understanding of how many could actually be seen during the day/night through personal experience, many might still wonder when are they most likely to spot more? So through observations and calculations scientist also concluded “The number is greater in autumn and winter.” NASA/JLP (2014).

**When can they be seen?**

As many people start thinking more rational they come to realize that shooting stars also occur during the day time, although they might not be noticeable, depending on location and time. Since there is no schedule for spotting shooting stars all the time, they can be seen at any given night. Although most people feel lucky to see a shooting star each night, they appear way more often than they seem to appear, “But since you can only see them at night, and you can only look at a small part of the sky at once, when stargazing you can expect to see a shooting star
every 10 to 15 minutes.” Curious about astronomy (2002). In lamer words “Meteor showers occur when Earth moves through a stream of particles produced by a decaying comet.” Delehanty, M. (2013). The reason on why shooting stars cannot be seen during day is because the sun’s light mainly blocks the fire of the shooting star which is what helps us spot them. The other thing to know would when spotting shooting stars is that location does matter at some points, because if living in a city where there is a lot of light, the city lights will block most stars in the sky. So remember to take out your telescope(s) at night to spot shooting stars since it just needs patients to spot one, also a good location such as camping wouldn’t hurt.

**Unique Characteristics**

Shooting stars to most people are a great unique mystery with extraordinary characteristics, such as their color, light tail, weight, and origin. By starting with the attention grabber, a shooting star’s color can vary in different glowing colors, “These ‘shooting stars,’ averaging about fifty per hour, are typically yellow and white, but they can be very bright green, orange, or red. Some leave spectacular trails up to two degrees wide (your thumb held against the sky at arm's length covers about two degrees) and last more than a minute” Cleere, G. S. (1993). What most notice during a meteor shower is the glowing trail of light that is left behind “But what causes the light path of the meteor that we can see in the sky? The light emission is mainly caused by interactions between evaporated and detached components of the fast moving meteoroid and air molecules. When the free electrons recombine with the ionized atoms in the tail of the meteoroid they emit the light that we can observe”. The trail of light can actually have a length of up to several tenths of kilometers and the colors are: the yellow color is caused by iron, a
blue-green color by copper and a red color by silicate material. Some shooting stars that are actually meteors can land on Earth by penetrating the atmosphere and can cause a serious impact, Such as the crater in Arizona that was caused by a 30 m wide, 100,000 ton meteor. The impact crater is 1.1 kilometers wide and 200 m deep. There is also the fascinating origin in which the shooting stars mainly come from, and as scientist have researched it is from the galaxy’s own Kuiper Belt.

Scheduled days

Astronomers actually have schedules days for a few shooting stars dates. They acquire these days through research and labeled the most unique. Some of the meteor showers are actually named by the astronomers and the upcoming showers are already named:

- Quadrantids
- Lyrids
- Eta Aquarids
- Comet 209P/LINEAR
- Leonids
- Geminids
- Perseids
- Orionids

(The website: [http://stardate.org/nightsky/meteors](http://stardate.org/nightsky/meteors) has scheduled the above meteor showers).

Once a shooting star passes the atmosphere they are called meteorites, which describes the well-known meteorite that fell on Russia on 15 February 2013. For the few who do wonder how to
best experience this shower before its too late astronomers advised “The best way to watch a meteor shower is to get away from the glow of city lights and toward the constellation from which the meteors will appear to radiate” Star Date (2014). Although meteor showers can be spotted during these days, lets not forget to keep our eyes open to the skies at night to witness to the next great meteor shower.

**Conclusion**

After researching shooting stars, many things have been learned through this experience. Such as the many names that shooting stars can have, such as meteors, meteorites, meteoroids, and many more. There is also the difference in the speed that they can travel, such as the average they travel in space and how it increases once passing through Earth’s atmosphere. The coloring of their light is also an interesting characteristic that shooting stars have as they leave the stardust trail. There is also the weight, which separates the small particles to the big heavy rocks, as most meteors we see are small rock particles with much speed and color. Lets not forget the origins of where most come from, which is from the Kuiper Belt. Also the very informative information on where and how the average person can witness the best experience to spot them.

- “Keep your eyes on the stars, and your feet on the ground”

*By: Theodore Roosevelt*
Annotated Bibliography


This source is useful to my topic as it discusses how meteor showers occur. It’s usefulness on this paper will help me write my paper as it also explains to the different coloring that shooting stars can have and when they were discovered.


This article helps explain just what shooting stars are and how often they occur. It mentions the time it takes for each shooting star and that they don’t just occur visible at night but as day as well.


This source explains the two main sources known as shooting stars and it mentions their average size. The other helpful information is how the meteors are produced.


This topic talks about the most the brightest and most impressive meteor showers to watch out for. Also talks as about the average speed a shooting star can have.


This article tells the average amount of meteoric material that falls on Earth each day. It also talks about the appearance it has as it is similar to Earth rocks but have a burn surface.


This source just like the similar one’s discusses what meteors are and their speed from lowest average to highest average. This also talks about the labels that are put on the meteor showers such as their names change when comparing from here on Earth to outer soace.

This article talks about the shooting star’s for 2014 as the new year begins. Also discussed the average time a meteor could be spotted in the sky.

http://eds.a.ebscohost.com/eds/detail?vid=4&sid=9ecaab7d-ec96-48bb-b714-46bbeafc5770%40sessionmgr4004&hid=4102&bdata=JnNpdGU9ZWRzLWxpdmUmc2NvcGU9c2l0ZQ%3d%3d#db=f5h&AN=20942155

Talks about the similarity on appearance that shooting stars have with actual stars and talks about their actual differences. It also gives tips on spotting shooting stars.

Star Date (2014). The University of Texas McDonald Observatory
http://stardate.org/nightsky/meteors

This article talks about meteor shower dates to look forward to. Also talk about what are meteors and shooting stars which are helpful to my topic.
The Kepler Space Telescope

Kent Roeckner

Paradise Valley Community College

Introduction to Solar System Astronomy – AST111

April 15, 2014

Professor J. Weitz
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Abstract

The Kepler telescope was launched in March 2009. Its mission is to detect changes in the brightness of stars caused by transiting planets, a process called the transit method. With its cameras pointed at the Cygnus constellation, Kepler has discovered 3,845 planetary candidates, 961 of which have been confirmed as planets, and 2,165 eclipsing binary stars (“Kepler | NASA” 2014). Kepler was the first telescope to discover multiple planets orbiting around a binary star system, and the first to discover a planet orbiting in a quadruple star system.

Introduction

After years of delays due to budget cuts and consolidation at NASA, Kepler was launched on March 7, 2009 at 3:49:57 UTC from Cape Canaveral, Florida on a Delta II rocket. On April 7, the cover of the telescope was jettisoned and its first light images were taken the next day. The commissioning phase was completed on May 12, and thus its search for planets in other solar systems began. On June 19, despite an unexpected safe mode four days earlier, downlinked the first of its scientific data to command centers on Earth.

The scientific objective of the Kepler telescope is to discover extrasolar planetary systems and explore the structure and diversity of planets in those systems. The mission is to specifically determine the number, as well as the range of size and shape of Earth-sized planets located in the circumstellar habitable zone, often referred to as “Goldilocks planets.” Other objectives of Kepler include estimating the number of multiple star systems and how many planets are in those systems, acquiring more information about the size, mass, and orbital characteristics of short-period giant planets, and learn more about the properties of the stars at the center of discovered planetary systems.
Review of Literature

The light detector setup on the Kepler telescope consists of an array of 21 modules, each with two charge-coupled devices (CCDs) that each produce an image with a resolution of 2200x1024 pixels (“Kepler: Target,” 2009). Collectively, this array produces an image of 95 million pixels. Kepler also has an aperture of 95 cm, compared to the 15-20 cm aperture found on most amateur telescopes. The primary mirror on Kepler is 1.4 meters in diameter and is 85 percent light weighted (“Kepler: About,” 2009).

The Kepler telescope has a fixed field of view across the sky. This field of view is situated just outside the constellation of Cygnus. To avoid coming into contact with sunlight, Kepler was placed in an orbit around the Sun, not Earth, and Kepler’s cameras were pointed 55 degrees from Earth’s orbital plane around the Sun. Additionally, the field of view required a large number of stars, but had to be off the galactic plane, in order to avoid confusion with all the disc-shaped mass of the Milky Way. Hence, the region along the Cygnus arm of the Milky Way was selected as the field of view for the Kepler telescope. The center of Kepler’s field of view has a right ascension of approximately 19h 22m 40s and a declination of approximately 44° 30’ 00” (“Kepler: Target,” 2009). The 21 modules that collect light on Kepler collectively cover a total of 100 square degrees, or approximately 0.25 percent of the sky. Hence, it would take 400 Kepler telescopes to cover the entire sky. For comparison, this field of view is about two scoops of the Big Dipper (“Kepler Media”).
Kepler discovers planets with a photometer. This photometer detects changes in a star’s brightness caused by the transit of planets across those stars. This method of discovering exoplanets is part of a process called the transit method. The amount the star dims depends on the relative size of the planet and its host star. A derivative of the transit method is called transit-timing variation (TTV). TTV asks whether transits of stars occur within a fixed interval of time or if there is a variation in the time between transits, hence the term timing variation (Holman & Murray, 2004). If the periodicity of transits remains fixed, than the object in question is confirmed to be a planet. TTV is useful in discovering planets outside the Solar System because the great distance of these planetary systems means that other methods of detecting planets do not work. There are, however, a couple disadvantages with the transit method. First, for a transit to occur, the view of the telescope, the orbital plane of the planet, and the star, must all be aligned. Only 10 percent of “hot Jupiters,” or Jupiter-sized planets that orbit close to their parent star, are aligned in a manner that allows a transit to be observed. Planets with smaller mass or larger orbits are even less likely to be aligned this way (“Transit Method,” 2012).

On May 12, 2009, shortly after the Kepler telescope was commissioned, a planet named Kepler-22b was observed transiting its host star, Kepler-22. It was further observed by the
infrared-based Spitzer Space Telescope, and on December 5, 2011, more than two years later, NASA confirmed the existence of the first planet found by Kepler that lies within the habitable zone where liquid water can exist on the surface. The new planet, despite having a radius 2.4 times that of Earth, is the smallest planet yet discovered orbiting in the habitable zone of a sun-like star. Scientists are currently unsure if the surface of Kepler-22b has a rocky, gaseous, or liquid surface, or the eccentricity of its orbit. Despite what little is currently known about Kepler-22b, there are hundreds of other planets in the same constellation that were discovered by Kepler alone (Johnson & Perratto, 2011).

The discovery of Kepler-22b was only the first of hundreds of new worlds that the Kepler telescope has brought to the public eye. There are thousands of stars that are suspected of hosting at least one transiting planet, which are referred to as “Kepler Objects of Interest,” or KOIs. KOIs are generated by the Kepler Input Catalog (KIC), which is a database of about 13.2 million targets used by Kepler to spot transiting planets (Brown, Latham, Everett, & Esquerdo, 2011). The first significant publication of data retrieved from the Kepler spacecraft was announced on Jun 15, 2010, when 706 stars were identified with exoplanet candidates ranging in size from that of Earth to larger than Jupiter. The majority of these planets have radii less than half of that of Neptune (Borucki et al., 2010).

Less than a year later, on February 1, 2011, Kepler released data for 156,453 stars observed and placed in the Kepler Input Catalog from the beginning of the mission on May 2, 2009 through September 16, 2009. During this period, the spacecraft discovered 1,235 planetary candidates orbiting 997 host stars. Of these candidates, 68 are roughly the size of Earth (1.25 Earth-radii or less). 54 candidates were found in the habitable zone with radii ranging from that of Earth to larger than Jupiter, six of which are less than twice the radius of Earth (Borucki et al., 2011).
On January 7, 2013, at the 221st American Astronomical Society Meeting, NASA and the Kepler team announced that there were 461 new planetary candidates, increasing the total number of candidates to 2,740 total planets orbiting 2,036 stars, an increase of 20 percent since the release of the previous Kepler catalog in February 2012 (“Announcing,” 2013).

Towards the end of February 2014, NASA announced that Kepler had discovered 715 new planets orbiting 305 different stars. Out of these planets, four are said to orbit in the habitable zone, and may be capable of supporting Earth-like life. With this discovery, the number of planets known to mankind has almost doubled. These findings are due to be published in March 2014 with two scientific papers in the Astrophysical Journal (Achenbach 2014).

As of March 2014, the official Kepler website shows a count of 961 extra-solar planets that have been confirmed to exist, 3,845 unconfirmed planetary candidates, and 2,165 eclipsing binary stars (“Kepler | NASA,” 2014)

In addition to thousands of new planetary candidates, Kepler has also broken new ground on binary stars. Based on the transit method of discovering planets, Kepler detects changes in the brightness of stars caused the transit of objects over those stars. Any object that Kepler sees transiting a star is labeled a planetary candidate. However, some objects fail some consistency test and are subsequently labeled as false-positives. Some of these false positives are later found to be binary stars, or a system of two stars relatively close together that orbit their common center of gravity. In a binary star system, the brighter star is called the primary star and the less bright star is its companion star.

On September 15, 2011, the Kepler team announced the discovery of its first circumbinary planet, a planet that orbits a binary star. The planet, Kepler-16b, is roughly the size of Saturn and orbits the binary star system Kepler-16 about every 229 days at a distance of 65 million miles. The primary Type K star and its companion Type M star orbit each other roughly
every 41 days. Kepler 16-b, despite orbiting just outside the habitable zone, is likely a gas giant with surface temperatures ranging from 170–200 K (−150 to −100°F). The planet has been nicknamed Tatooine, a reference to the fictional planet from the Star Wars series. Tatooine, like Kepler-16b, orbits a binary star system with a yellow star and a red one, and double sunsets can be observed on both planets (“From Star,” 2011).

One year later, on August 28, 2012, Kepler observed two planets orbiting the binary star Kepler-47, marking the first time that the Kepler telescope has observed multiple planets orbiting multiple stars, and the first time that such a system was confirmed. The first planet, Kepler-47b,
is a gas giant with an orbital period of less than 50 days and a surface temperature resembling that of Mercury. The second planet, Kepler-47c, orbits within the habitable zone and has a radius four times that of Earth ("Kepler-47," 2012). This discovery is significant because previously, it was believed that it was impossible for binary stars to host multiple planets. Scientists believed that gravitational perturbations would cause the circumbinary planets to collide with each other, with one of the parent stars, or be flung out of orbit entirely. However, with the discovery of the Kepler-47 planetary system, it is now understood that planetary systems with multiple planets can exist with more than one star, just as a regular planetary system with one star ("Tatooine-like," 2012).

Adding to the list of extrasolar planet firsts, a group of amateur astronomers called Planet Hunters, using data from the Kepler telescope, discovered Kepler-64b, a transiting planet in a system of four stars. The discovery, announced on October 15, 2012, is the first known circumbinary planet to orbit in a quadruple-star system. This planet, also known as PH1b, is 20-55 times as massive and 6.2 times as large as Earth, making it about as large as Neptune. The planet actually orbits a close binary star, with a more distant binary star orbiting at 90 billion miles (1000 AU) away (Schwamb et al., 2013).

However, Kepler’s capacity to function in the future may be limited. In order to remain balanced while in space, spacecraft use certain flywheels called reaction wheels to control their orientation in the field of space. Their use is necessary in space telescopes in order to maintain its position and keep the cameras fixed on a certain field of view. Without these reaction wheels, the telescope would have to rely on small rocket thrusters to change its position or hold steady, using up valuable rocket fuel. The Kepler telescope is equipped with four reaction wheels, and needs at least three functional wheels in order to precisely point itself towards the stars.
In July 2012, one of Kepler’s reaction wheels failed. On May 11, 2013, another wheel failed, meaning Kepler will not be able to point precisely at its field of view. Since then, Kepler has not collected any scientific data due to this failure. In order to function properly, reaction wheels must rotate in both directions with minimal friction. The two wheels were tested in July 2013, and the results showed that the wheels were able to rotate, but with too much friction to be useful. NASA cannot simply send astronauts to repair the reaction wheels as they did with the Hubble Space Telescope, because Kepler orbits the Sun and is millions of miles away from Earth (Wall 2013). Therefore, the future of the Kepler mission remains unclear.

On the bright side, there is still a mountain of data from the Kepler telescope that has yet to be analyzed. Of the 3,548 planetary candidates detected by Kepler to date, 135 have been confirmed as planets since May, and 90 percent of the ones remaining are expected to be confirmed, a process that may take several years to complete (Wall 2013).

**Conclusion**

In conclusion, the Kepler telescope has discovered hundreds of planets beyond our Solar System, but is only the beginning of a great quest for other worlds. Kepler has provided valuable information about the structure of other planetary systems as well as binary star systems. Kepler proved that multiple planets can orbit a binary star, and also found the first planet in a quadruple star system. We should not be discouraged by the failure of Kepler’s reaction wheels. It would take 400 Keplers to cover the whole sky, leaving millions of possible Earth-like planets within our view. There are plans to send successor telescopes into space that would cover a much larger portion of the sky. This quest for new worlds would last for decades to come.
Sources Cited


Touch Screen Devices

Ashley Schopp
Physics 112
Dr. Casey Durandet
11/18/13
Abstract

Touch screen technology seems easy and simple at first. Simply touch the screen on your device and it knows just what needs to be done when that spot is being touched. What people do not know is what exactly is going on when they touch their finger to their device’s touch screen. Touch screens are made possible because of one simple thing, electric fields. There are many different kinds of touch screen systems, resistive, capacitive, surface acoustic wave, and infrared. Each one manipulates touch screen technology in a different way. Even though we have much progression with touch screen technology, there is always room for improvement within each kind of touch screen system.

Introduction

It seems like these days, we are living in a world where our technology is more “touchy feely”. Everywhere, touch screens can be seen in all of our everyday devices. For example, they are in smart phones, tablets, satellite navigation systems, video games, and even computer screens. For consumers, a touch screen is the way to go for all devices. This is due to the fact at how simply it is to control your device with just a touch of your finger. Your finger will always be with you and you don’t have to carry around a mouse or keyboard with you. No wonder why touch screens are so popular. To us, the touch screen is a newer idea for technology and our devices, but actually it was first invented way back in 1968.

E.A Johnson first developed the touch screen at the Royal Radar Establishment in England. He developed a screen that was used for air traffic control in the UK. The only reason why people back then didn’t have access to touch screens was because it was never manufactured for consumers. This screen that he developed was actually the precursor for screens on ATMs, ticketing machines, and outdoor kiosks. For the past couple of decades, scientists have used and developed different techniques to progress touch screen technology. These range from mechanical, optical and electrical sensing to detect a finger touch on a screen. Touch screens are much more complex than just simply touching your finger to a screen to make it work. So the real question of this paper is: How exactly do these popular touch screens work?
Advantages of Touch Screens

There are many advantages to the touch screen technology. Touch is one of the most natural and intuitive senses that the human body has. Everyone knows how to point a finger and touch an object. Touch screens are also easy to use and since you’ll always have your finger with you, at least let’s hope, you’ll never be anywhere without it. Using a touch screen device is less intrusive and distractive versus clicking or typing when using a mouse or keyboard. This is especially important when in a business meeting or other social situations. Another advantage is the fact that it’s portable because you don’t have to carry around a mouse or keyboard with your computer. This enables users to use a computer in different environments and scenarios.

Three Main Components of Touch Screens

Some people may think that touch screen technology is just a screen that is covered by glass and when you touch a part of that glass, that device just knows where the device is being touch and what to do. But in fact all touch screens have three main components, the touch sensitive surface, the controller, and the software driver. These components act as a team to identify the location of the touch and what to do when that location is being touched.

The touch sensitive surface is made of flexible glass that is extremely durable. It is placed over the viewable area of the screen. This is underneath the glass that gets touched by the person using the device. An electrical signal goes across this screen and when the user touches the screen, it causes a change in the electrical signal. This change in the signal allows the controller, the next main component of touch screens, to identify the location of the touch.

The controller acts as an interpreter or intermediate between the screen and the computer. It takes the electrical signal of the touch and interprets it into a digital signal so that the computer of the device is able to understand.

The software driver of the device is also an interpreter except it converts the signal from the controller to information that the operating system in the device can read and understand.

Besides these three main components, there is one other thing that all touch screens have in common. All touch screen devices depend on the natural element called indium. Indium is rare and scarce on this planet. This element has uncommon properties that help touch screens work. They are good conductors of electricity and when the element is in thin layers, it is transparent. Virtually all touch screens contain two ultrathin sheets that are made of this element.
The Electric Field

Electric fields are what make the touch screen able to work. An electric field is the attraction between opposite charges. When these charges are separated by energy, the field spreads out in all directions. The more negative and positive charge that can be separated, the stronger the electric field becomes between and around them. This separation is what creates voltage or potential difference. Electric fields virtually are everywhere. We can’t necessarily see them but sometimes we can feel them. For example, we have electrical fields in our own body. Our cells expend a great amount of energy pumping charges in and out of the cell membrane to make sure that the inside of the cell stays more negative than the outside of the cell. Our bodies have sodium, potassium and other elements to pump in and out to do this. The separation of the charges creates this electric field and therefore a potential difference. This potential difference is what controls enzymes and the gates that are in the cell membrane. Our nerve cells also use electric fields to work.

In a touch screen device, there are two pieces of glass, on piece of glass has an electric field going in a vertical direction and on the other piece of glass the electric field goes in a horizontal direction. This makes a grid pattern of wires that are so tiny they cannot be seen on the device. There are also hidden sensors at the edge of each intersection of the wires. This is the key to touch detection on the device. The wires on one side of the...
glass are connected to the positive terminal of the battery of the device and the wires on the other side are connected to the negative terminal of the device. Even though the electric fields are really small, they are sensitive to changes around them. So when your finger touches the screen, it causes a change in the electric field by the positive wires and negative wires touching due to the pressure of the finger.

**Different types of Touch Screens**

1.) **Resistive touch screen systems**

With these types of touch screens there are two thin metallic layers separated by spacers. An electrical current runs between the two layers and when the two layers make contact due to the pressure from the touch, this creates a change in the electric field. This change is understood by the operating system of the device. This is how the device knows what to do at the exact spot that was being touched by the user.

![Figure 3: As the two layers make contact from the touch of a finger, the electrical field changes which is understood by the operating system of the device.](image)

2.) **Capacitive touch screen systems**

These systems have the same setup as the resistive touch screen systems except they have a special layer that stores electrical charge. They use a capacitor to store this energy. A capacitor is an electrical current that has two opposite conductive electrodes that are used to store energy in an electric field. Just like the resistive touch screen systems, one electrode is connected to the positive terminal of the device's battery and the other electrode is connected to the negative terminal of the battery. When the screen of the device is touched, some of the charge is transferred to the user. This transfer of charge is detected by the operating system due to the fact that the charge decreases.

For the touch screen to work correctly, some of the charge must be transmitted to the user. This is why wearing gloves while touching a touch screen device with this kind of system doesn’t work. It blocks the transmission so the device cannot detect the touch. With the electricity from the human finger, it allows the device to be induced by a corresponding current and makes the capacitive circuit complete. This makes it easy for
the device to detect the touch. Today, these kinds of touch screens are newer and the most popular in touch screen devices\(^3\). It has been proved that these touch screens are the most versatile and effective way to detect human touch\(^3\). They also transmit more light and give a clearer picture without being really expensive.

![Capacitive touch screens work with a special layer between two pieces of glass that stores electrical charge. When there is a change in this charge, which occurs when a finger touches the screen, the operating system detects this and knows exactly where the touch occurs.](image)

3.) Surface acoustic wave touch screens

This type of system relies on sound waves in order to work correctly. It uses transducers and reflectors to measure changes in the reflection of ultrasonic waves caused when the finger touches the screen on the device\(^11\). Two transducers are at two of the corners and two receivers are set at the opposite corners of the screen\(^7\). When the screen is touched a sound wave travels parallel to the edges of the screen. As the wave hits the reflectors, the wave gets transmitted to the transducers then the receivers\(^7\). These systems are the most advanced and have the clearest picture\(^11\). These screens are the most durable and scratch resistant. They can also be used with gloves or a stylus. For this reason, these screen systems are also the most expensive. This is why most devices do not have this kind of touch screen.
4.) Infrared touch screen systems

These types of screens are used mainly for larger screens like banking machines or for military applications\(^{11}\). They are based on light-beam interruption. A frame surrounds the display and has light sources. This light sources or light emitting diodes (LED) are on one side and the detectors are on the other side\(^{11}\). This creates an optical grid on the screen. When a user touches this grid, the light beam is interrupted and is detected by the operating system of the device.
The Smart Phone

Nowadays, everyone who is anyone has or at least has heard of a smart phone. They call it a smart phone because of all the possible things it’s able to do and accomplish. One thing in common with all smart phones in this day and age is the fact that they all have touch screens.

Smart phones with touch screens consist of two sheets of glass that are separated with a bunch of transparent wires arranged in a grid pattern. These wires form dozens of small electric fields forming and disappearing in this grid pattern. This is the key to touch detection. The device can pinpoint the touch by having this grid pattern. On one side of two pieces of glass the wires are arranged horizontally and on the other side the wires are in a vertical pattern. One set of the wires is hooked up to the positive terminal of the device’s battery. These wires have their electrons sucked out of them. The other set of wires is hooked up to the negative terminal of the device’s battery. These wires get electrons pumped into them. This allows the device to always have one wire of the pair that is more negative than the other.

This difference in charge causes an electric field between the two wires. The electric field is the strongest wherever the two wires are the closest. The glass used on the smart phones is an insulator and therefore doesn’t conduct electricity and current does not flow from it. The electrons from the glass, however, are being pulled closer to the positive wire and are repelling the electrons in the positive wire. This attracts more electrons from the battery to the negative wires. So the positive wires gets more positive and the negative wires are getting more negative. This creates a stronger electric field.

When a human finger touches the phone screen, these wires get closer together creating a stronger electric field to occur. This causes a change that can be detected by the controller of the device and then interpreted so that the operating system can understand where the touch is and what needs to happen when that spot is being touched on the device.
Conclusion

Touch screen technology depends basically on one thing and that is creating an electric field between two sheets of glass. Not knowing this before, I always thought that it worked because of pressure from the finger on the screen. In fact there is much more to this kind of technology then just putting your finger on your devices screen.

From looking a little bit more in depth of how touch screens really work, it seems like there is a lot of room for improvement in this kind of technology. This paper discussed four different types of touch screen systems and with more research; each one can be improved to better the technology.

It may seem like we have done all there is with the touch screen technology. However, there is a lot of progression we can look forward to. Researchers are looking to progress this technology in any way they can. They are trying to make the screens more durable and dirt resistant without having them cost an arm and a leg. Apple just came out with their new iPhone 5s where the lock screen is now unlocked with our fingerprint. I think we will see a lot more devices with fingerprint capabilities. This is a great idea since everyone has a different fingerprint and it is always with you. It is also a way to prevent fraud since not one fingerprint is the same. Touch screen technology is complex and I think there is a lot more we can learn to make it even better.
Bibliography


Solar Activity

Michelle Scott

Professor Weitz

AST 111

14 April 2014
Abstract: Our very own star of the solar system, the sun, is a mystery. This gigantic mass is very active and scientists are working to discover its pattern of activity. Solar activity includes: solar flares, coronal mass ejections, solar storms, sun spots, coronal rain, and auroras.

Our star is approximately 330,000 times the mass of Earth. About three quarters of the Sun's mass consists of hydrogen, and the rest is mostly helium. The small remainder consists of heavier elements including oxygen, carbon, neon and iron. The sun is now thought to be brighter than about 85% of the stars in the Milky Way. Its average temperature is 27,000,000 degrees Fahrenheit.

We have only recently been able to see what inside the sun and understand its processes. The core is plasma, similar to lightning that we have on Earth. Plasma is a collection of charged particles containing equal numbers of positive ion and electrons. It exhibits some properties of gas but is different because it conducts electrify and is affected by a magnetic field. Nuclear fusion takes place in the core. Nuclear fusion is a nuclear reaction in which two or more atomic nuclei collide at a very high speed and join to form a new type of atomic nucleus. This atomic process is the same thing that occurs in the hydrogen bomb. Photons are made every second. This huge conversion of mass to energy creates the equivalent of 10 billion hydrogen bombs per second (Copp). So why doesn’t the sun blow itself up? The gravitational force from the outside balances the explosive power from the inside. The sun has been doing this for 4 billion years and will continue to do this for about another 4 billion years.

Outside of the core is what is called the radiative zone. Photons slowly bounce through plasma here. It takes photons 100,000 years to get through this zone. The energy made in the core is in the form of photons, more specifically in gamma rays, when it first begins its
journey outward. This energy is changed into less energetic photons as it moves through the radiative zone. This is especially good news for us because gamma rays are very harmful to humans (Web). The next layer of the sun is the convection zone. Radiation moving out from this part of the Sun gets absorbed more readily, reducing the amount that actually makes its way out of the Sun. This makes the gas unstable, and leads to convection. In the convective zone, the energy is transferred much faster than it is in the radiative zone. The convective zone is cooler than the radiative zone and therefore less dense (Web). It takes a month to get through this zone. Since the sum of these processes take a very long time, the sunlight that shines on us today was made during the last ice age (Copp).

The sun and its layers can be thought of as a massive lava lamp. When plasma and cells are hot, they rise to the top. From there, it cools at the top, gets dense, and falls back down. This is called granulation and it can be viewed on the sun’s photosphere. The photosphere is a very thin part of the sun’s atmosphere. Additionally, it is the only part of the Sun that we can actually see when looking at it from Earth, because the photosphere is where the light is emitted (Web). The next layer of the sun is called the chromosphere. A lot of other solar events take place within the chromosphere also, such as solar flares (Web). The sun’s atmosphere, called the corona, is 300 times hotter than the sun’s surface. The corona is the collection of immediate gases around the Sun. Corona is a word that means crown. It’s like the hot bright crown of the star.

The magnetic field of the Sun is the origin of solar activity. Solar flares are areas around sunspots that appear to brighten sharply through a telescope because of an enormous energy release. They are distinguished from other solar activity in that they happen so suddenly. They can last between a few minutes to a day and are extremely hot. There are two
ways that a solar flare can be observed, on the disk and on the limb. When seen on the disk, a
darkening appears and then a rising in an active region. Then two bright areas appear as
ribbons. They expand rapidly and get extremely bright, and the ejection occurs at this point.
When seen on the limb, a bright point appears and develops into a beaming mass of emission.
During the onset, surges and sprays are often seen (Web). These are known as some of the most
spectacular occurrences in our solar system.

The corona blasts coronal mass ejection waves toward earth. Coronal mass ejections are
large bubbles of gas that cause particles to be ejected into the solar wind. Violent eruptions shoot
tons of charged particles into space at two million miles per hour (Copp). The magnetosphere of
the Earth helps protect it from the solar wind. Now we will go into a little bit more detail as to
how the Sun's activity works within the interplanetary magnetic field. The coronal mass
ejections and solar flares that come from the sun often hit the Earth's magnetopause. This creates
changes within the Earth's magnetic field. The normal configuration of the field is disrupted,
causing the particles within it to flow differently. This can be harmful to Earth, and cause
damage to equipment and even humans. CME’s can destroy Earth’s power grid- massive
electric surge overwhelms power lines. Coronal mass ejections are often associated with solar
flares and prominence eruptions but they can also occur in the absence of either of these
processes. The frequency of CMEs varies with the sunspot cycle. At solar minimum we observe
about one CME a week. Near solar maximum we observe an average of 2 to 3 CMEs per
day (Coronal). There are NASA scientists that observe these CMEs on huge television screen
daily.
All of this data and observation is possible thank to the Solar Dynamics Observatory. It is a satellite that gives is high resolution coverage of the sun. Scientists have the luxury of having constant viewing access of what the sun is doing. SDO gives them the capability to see the sun in different wavelengths (Copp). In August 2012, the SDO caught an amazing whip-like solar filament which was half a million miles long. It formed an arc above the sun’s surface and could be viewed over the period of 3 Earth days. Scientists are trying to predict when the next solar storm will hit and if it will affect us on earth (Hill). With this new technology, researchers can view solar flares, magnetic fields, and sunspots.

Solar flares are crossing magnetic field lines. Solar flares occur in regions of concentrated magnetic field such as sunspots (Young). This violently shoots plasma loops into space. Sunspots can linger on the sun surface for weeks. These are cool spots on the sun due to the magnetic fields being so strong that they suppress the flow of heat from below. This is also a breeding ground for solar storms. The number of sunspots waxes and wanes over a cycle of 11 years. The sunspot number is calculated by first counting the number of sunspot groups and then the number of individual sunspots. Although sunspots themselves produce only minor effects on solar emissions, the magnetic activity that accompanies the sunspots can produce dramatic changes in the ultraviolet and soft x-ray emission levels. These changes over the solar cycle have important consequences for the Earth's upper atmosphere (The Sunspot). The regions overlying sunspots are called active regions. Here the sun’s magnetic field becomes concentrated and twisted because of the motions of the solar atmosphere at and below the solar surface. As these regions become more complex they can eventually become unstable causing the release of the magnetic energy (Young). The sun in this regard is a delicate balance of energy that can be thrown off kilter and become stronger than it looks.
Magnetic poles reverse during these cycles as well (Copp). Maximum activity always occurs just before a regular flip in the polarity of the sun's magnetic field (Owens). The sun’s magnetic poles flip their location on the sun every 22 years, called the Hale Magnetic Cycle (Young). As a point of comparison, Earth’s magnetic poles reverse their geographic locations every 300,000 years. The last event happened 780,000 years ago.

One part of solar activity that we are able to see with the naked eye is auroras. Auroras are a natural light display in the sky particularly in the high latitude regions, caused by the collision of energetic charged particles with atoms in the high altitude atmosphere. The charged particles originate in the magnetosphere and solar wind and, on Earth, are directed by the Earth's magnetic field into the atmosphere. Named for the Roman goddess of dawn, the aurora is a mysterious and unpredictable display of light in the night sky. The aurora borealis and aurora australis – often called the northern lights and southern lights – are common occurrences at high northern and southern latitudes, less frequent at mid-latitudes, and seldom seen near the equator. Auroras are a spectacular sign that our planet is electrically connected to the Sun. These light shows are provoked by energy from the Sun and fueled by electrically charged particles trapped in Earth’s magnetic field. While beautiful to behold, they can be a nuisance to those who depend on modern technology. The color of the aurora depends on which gas is being excited by the electrons and on how much energy is being exchanged. Oxygen emits either a greenish-yellow light (the most familiar color of the aurora) or a red light; nitrogen generally gives off a blue light. The oxygen and nitrogen molecules also emit ultraviolet light, which can only be detected by special cameras on satellites. (Young).

In short, the sun is a gigantic ball of constant craziness. It’s always producing energy, has been doing so for a very long time, and will continue to do so for a very long time. It’s our solar
system’s special, singular star, and we depend on it for life on Earth. There is a plethora of activity going on in our dear star and scientists and scholars are still in awe over the things it can do. We are on a continuous quest for solar knowledge.


The Effect of Microgravity on the Human Body

Michelle C. Simon
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Dr. Durandet
Abstract

Normal body processes need gravity in order to function properly. The force of gravitation is lost while in space, which leads to an array of system irregularities. The systems that are affected the most by microgravity are the cardiovascular, skeletal, muscular and fluid regulation. While in space, astronauts exercise, eat a special diet and monitor each system with numerous devices. Some of the greatest technology has been developed due to space travel, some of these include RED, CEVIS and TVIS.

Introduction

The human body is a very complex piece of art. Through various forms of research, we have obtained thorough knowledge of how certain systems of the human body function. Understanding the human body and its processes is a very useful tool, especially when it comes to new treatments and cures for diseases and disorders. Using space exploration, researchers can further investigate the human body by understanding the importance of gravity and the effect of microgravity. Unfortunately, the transition from gravitational pull on Earth to microgravity in outer-space takes a huge toll on the human body; temporarily disrupting normal physiological functions. The main systems that are affected the most by space exploration are: cardiovascular, skeletal, muscular, fluid regulation and the neurovestibular organs. The extent of damage also depends highly on the amount of time spent in space and the system’s efficacy to recover.

Normal cardiovascular function

In order to understand the deleterious effects of space travel, it is essential to know the normal physiology of the systems that experience the most harm. One of the first systems of discussion is the cardiovascular system. The cardiovascular system contains the heart, the blood vessels and the blood that travels through these vessels. This system is pressure-driven and is used in many physics texts as an example of pressure. Pressure is described as the force divided by the area; blood pressure is the force of the blood exerted on the walls of the blood vessels. The heart pumps blood throughout the body. Blood that leaves the heart in arteries and blood comes back to the heart in veins. Flow through the blood vessels relies on the pressure and resistance of the vessel to blood flow. Gravity plays a major role in blood flow. While a person is standing, gravity pulls the blood toward the lower extremities. Due to gravitational pull, it is harder for blood to make its way back up to the heart and lungs for oxygen. Fortunately, the human body is equipped with a mechanism to counteract the effects of gravity. When the lower extremities or legs move, they contract. This contraction of the muscles shunts blood back up to the heart and lungs through the veins in the calves (refer to Figure 1). Blood is composed of plasma, platelets, red and white blood cells. The plasma is the watery portion of the blood and is about 55% of blood’s volume. Red blood cells are responsible for transporting oxygen from the lungs to the other regions of the body. Red blood cells make up 40-50% of the total blood volume. White blood cells are part of the immune system and make up 1% of the blood volume.

Cardiovascular system function during space travel

When in space, there is no gravity and thus no gravitational pull of blood to the lower extremities. Instead, blood pools in the chest cavity and head, this phenomena is known as headward shift. This causes astronauts to have puffy faces and bulging blood vessels in the neck.
region. The fluids fill cavities within the head that are normally dry, resulting in the fuller or “puffiness” (refer to figure 3). Since there is less fluid distributed to the lower extremities, legs are often smaller in circumference. The smaller legs are referred to as “bird legs.” The heart functions relatively normal, if not better because it does not have to fight gravity and thus pumps with more ease. The long term effect is that the heart becomes deconditioned; resulting in the fluid redistribution described above and atrophies or reduces in size. The plasma portion of blood decreases with space travel, whereas the level of red blood cells either remains the same or decreases. The occurrence of decreasing red blood cells in space is known as space anemia and relies on many other factors, such as fluid excretion and muscle loss.

Normal fluid regulation

The fluid within the body is distributed into fluid compartments, which includes intracellular fluid, extracellular fluid and interstitial fluid. A portion of the bodily fluids is found in the plasma of blood. Fluid balance within the body means that the intracellular and extracellular fluid levels are relatively constant. It is maintained by mechanisms that adjust fluid output in response to the amount of fluid intake and adjustment of fluid intake based on fluid needs of the body. The kidneys and hormones produced in the adrenal and pituitary glands aid in the regulation of fluids within the body. The kidneys are responsible for filtration, reabsorption and secretion of water and nutrients (refer to figure 4). Anti-diuretic hormone, which is produced in the pituitary gland, is secreted to decrease urine formation. Sensors within the hypothalamus sense salt concentration in the fluids. In response to high levels of salt, it signals the pituitary gland to secrete ADH. ADH travels through the blood to the kidneys, where it causes the kidneys to reabsorb more water into the bloodstream. Aldosterone is the hormone produced within the adrenal cortex of the adrenal glands. This hormone relies on the concentration of potassium in body fluids; higher levels signal the adrenal cortex to secrete aldosterone. Aldosterone, much like ADH, makes its way to the kidneys. However, aldosterone signals the kidneys to reabsorb water and sodium, but stop reabsorbing potassium back into the bloodstream, which causes potassium to be excreted through urine.

Fluid regulation in space

During launch, astronauts are seated with their back flat and legs and feet up (refer to Figure 2). Fluids redistribute to the chest cavity, where the body senses the increase in fluid volume. The body’s response is to try and eliminate this extra fluid volume. The result is an increase in urine production and excretion. Astronauts may lose up to one liter of urine upon launch. The loss of fluids will continue while in space, but the feeling of thirst does not occur. Therefore, astronauts decrease their intake well below their normal intake. The increase in fluid elimination and decrease in fluid intake reduce the level of bodily fluids below Earth normal levels. The lack of thirst is most likely due to the secretion of hormones in response to the sensation of increased fluids that signal the kidneys to produce more urine, which reduces the body’s need to consume liquids.

Normal muscular function

The human body has three types of muscle: Cardiac, Smooth and Skeletal. Cardiac and Smooth muscle are involuntary and are found within the organs and blood vessels. Skeletal muscle is the only muscle group that is voluntary. This simply means that we can control the
actions of these muscles; in comparison, we cannot tell the heart to beat or the blood vessels to contract. Skeletal muscle has one major function and that is movement or locomotion. All three groups of muscle create movement by contracting muscle fibers. The two types of muscle fibers: Type I or slow twitch and Type II or fast twitch. Slow twitch fibers can contract for a long period of time before they start fatiguing. Fast twitch fibers contract quickly but fatigue very quickly. There are a number of muscles that are referred to as postural or anti-gravity muscles that aid in counteracting gravity (refer to figure 5 ). These muscles are composed of primarily of Type I muscles.

**Muscular system function in space**

Microgravity is physically undemanding. Therefore, the muscle contraction that is essential to life on Earth does not occur because astronauts do not exert these muscles for support or movement. Since these muscles are minimally contracting, they start to lose strength and deteriorate. This is known as muscle atrophy. Within an 11 day spaceflight, astronauts can lose up to 20% of their muscle mass. This percentage increases with longer flights. Muscle atrophy is an incredibly dangerous situation for astronauts. They need strong muscles to operate machinery in case of an emergency procedure during re-entry onto Earth. The good news is that muscle mass and strength can be recovered after homecoming.

**Normal Skeletal function**

The muscles are reliant on the skeletal system. The skeletal system consists of the bones, cartilage, ligaments and tendons. The skeletal system provides the framework of the human body and supports muscle movement. Bone is formed by osteoblasts, which later mature into osteocytes. Bones also contain blood vessels, collagen and nerves. Another important bone cell is the osteoclast, which break down old bone formation in preparation for new bone growth. New bone formation is known as ossification. Embryonic ossification is broken into two parts: intramembranous and endochondral which form intramembranous bones and endochondral bones, respectively. The endochondral ossification provides tensile strength and intramembranous ossification provides compressional strength; bone cannot withstand twisting or torsional strength.

Intramembranous ossification begins by forming sheets of connective tissue; osteoblasts are present in these sheets. Osteoblasts then deposit extracellular matrix into these sheets, which forms spongy bone. The matrix is composed of collagen fibers and crystalline salts, mostly calcium and phosphate. The calcium and phosphate salts form hydroxyapatite crystals. The matrix hardens and the osteoblasts get trapped; once this occurs, the osteoblasts become osteoclasts and the sheets become the periosteum. During endochondral ossification, hard bone replaces the model or hyaline cartilage. The osteoblasts get trapped along the edges of the forming bone, depositing extracellular matrix on the outside of the previously formed spongy bone. Postembryonic bone formation occurs by widening and lengthening the bone. Widening of the bone is the most significant topic for this paper. Widening of the bone occurs by the accumulation of osteoblasts on the outer edges of the bone, which deposits more extracellular matrix, thus widening the bone.

Bone development is influenced on numerous factors, including hormones, sunlight and exercise. Two major hormones that are affected by calcium levels and affect bone growth are...


parathyroid hormone and calcitonin. Parathyroid hormone is secreted in response to low levels of calcium and calcitonin is secreted in response to high levels of calcium. Sunlight also aids in bone development. The sun emits ultraviolet rays that signal the skin to produce Vitamin D. Vitamin D is required for proper absorption of calcium in the small intestine. Bone deposition is also dependent on the physical stress on the bone. Continual physical stress encourages calcification and deposition. The bones of the lower legs are referred to as anti-gravity bones because they oppose gravity (refer to figure 6).

Skeletal system function in space

Calcium is lost from bone on a regular basis, but on Earth calcium loss and calcium deposit are balanced. This balancing act is part of homeostasis. In space, astronauts experience microgravity and float. The calcium loss is very slow, but the rate of deposition is much slower. Therefore, the bones become very brittle and more susceptible to fractures. The rate of loss is not the same in all bones; weight bearing bones like the femur tend to become weaker faster than upper body bones. Within a several month flight, BMD can be reduced by as much as 20%; 100 mg of calcium can be lost per day. However, on shorter flights, BMD loss is not reduced enough for an increased risk of bone fractures. Bone mineral density returns to normal levels several months after a spaceflight. Mineral loss from the bones releases calcium into the blood stream. The blood stream carries calcium amongst other minerals to the kidneys, where, under normal conditions, the minerals would be filtered out into urine. Unfortunately, elevated calcium levels extended periods or hypercalciuria, can lead to kidney stones.

Neurovestibular normal function

The neurovestibular system is the part of the nervous system that controls balance. Gravity is detected by the body in the otolith organs, which includes the utricle and saccule. The otolith organs are composed of hair cells covered by calcium carbonate crystals that surrounded by a gel-like substance (refer to figure 7). The semicircular canals in the inner ear detect rotational movements made by the head. When the head is in its normal erect position, the hairs of the utricle lay almost horizontally while the hairs of the saccule stand vertically. Signals are sent to the brain based on the movement of both the utricle and saccule hairs. Together these organs help the body understand its movement.

Neurovestibular system in space

Microgravity disorients the otolith organs; no vertical reference signal is sent to the brain. In layman’s terms, the brain gets confused. The brain relies on all senses to stay oriented and balanced. This may give the impression of being upside down when right side up; there is no apparent sense of direction. This new environment often results in space motion sickness at the beginning of a mission. The astronaut may feel dizzy until he or she adapts to microgravity. The body adapts quickly to Earth’s gravitation after spaceflights.

Maintaining Normal Function in Space

The first step in maintaining normal physiological function in space is to train on Earth. This is made possible by using a tilt-translational device (TTD) and the device for orientation and motion environments or DOME (refer to figures 8 and 9). These devices are used specifically for the neurovestibular system. They expose astronauts to some of the same stimuli
experienced in space. This makes it quicker for the body to adapt to these stimuli in space and can help reduce the duration of space motion sickness and disorientation.

Exercise is essential before, during and after spaceflights. Pre and post-flight, eye and body coordination is tested using the Thera ball exercise; an astronaut throws the ball into a designated area while trying to keep their balance. The 30-movement agility test also tests coordination; astronauts are timed on how long it takes to perform 30 movements. Daily exercise is required to keep all systems functioning properly. The exercises performed on a space shuttle are intense; 2 hours of exercise are performed daily. Three types of equipment are used for in-flight exercise: RED, CEVIS and TVIS. Resistive exercise device or RED is a device (refer to figure 10) that mimics the gravity on Earth, allowing astronauts to perform weight-bearing exercises with resistance. Cycle Ergometer wit Vibration Isolation System or CEVIS (refer to figure 11) is much like a mechanical bike one may see in a gym. However, the bike is bolted to the floor and astronauts must snap their shoes into the petals as well as wear a seat belt. The resistance can also be adjusted on a CEVIS. Treadmill Vibration Isolation System or TVIS (refer to figure 12) is also like a regular treadmill, but it is free-floating. Bungee-like cords hold it together and the astronaut strap a belt cord to them and walk. Together, these devices help to combat the destructive nature of microgravity on the muscular, skeletal and cardiovascular systems.

In combination with exercise, other technological devices are used to monitor these systems. Electromyography machines were too bulky to transport on a shuttle, so the MyoMonitor© EMG System was created to measure muscular performance. Bone mineral density is measured using a Mechanical Response Tissue Analyzer. This device measures bone mineral content, stiffness and bone strength and density. Another innovative device is the G-suit or anti-gravity suit. This suit is worn by astronauts during the transition from Earth to space. The suit contains bladders or pressure balloons that expand with air and push on the legs. The astronaut allows the air to enter these bladders to push blood up into the upper body; it makes it easier for the heart to pump blood. During launch, astronauts can lose up to a liter of urine, so astronauts must wear diapers. These diapers are not like baby diapers, they are super absorbent and durable enough to hold all that urine.

Diet is very important during space exploration. As mentioned, the body loses minerals and nutrients within the bone. Therefore, special diets have been formulated so that the crew receives 100% of the daily value of vitamins and minerals. Space food has improved greatly within the last 40 years. Astronauts do not receive “mystery food” but rather have the option to have regular everyday foods like fettuccini alfredo.

Conclusions

Space exploration has proven to have an overall negative affect on human physiology; it hinders the body’s ability to function normally. However, technology and research have helped us understand create devices and equipment that can counteract the negative effects of microgravity. This can be incredibly useful here on Earth to help researchers and doctors design new treatment plans for patients experiencing the same adverse effects that microgravity has on astronauts, like bone mineral density loss. Diseases or disorders that can benefit from space travel include but are not limited to: heart failure, high or low blood pressure, osteoporosis, motion sickness, etc. Gravity is very important to human physiology, but microgravity may be
much more important to our overall existence and success. The research that is performed in microgravity helps us better understand the way our body systems work together. However, it is very important for astronauts to train their body’s prior to space travel to reduce or limit the effects of space travel. This is why training begins months to years prior to the actual space flight. The human body can adapt fairly easy to microgravity, but we are still investigating why certain conditions happen and why other conditions resolve themselves. In the past 40 years or so, space exploration has reached new heights. I believe that the future holds many more great triumphs for space exploration as well as for human physiology. I also think that we can use the research gathered within each flight to help humans on Earth, but to also make spaceflights longer in duration, allowing us to travel far beyond where we have today. This may take many, many more years or decades, but I do think it is possible.

Figure 1: Counteracting gravity in the legs

Figure 2: Launch Position

Figure 3: Normal shape of the face (left) and “puffy” face (right)
Figure 4: The kidneys

Figure 5: Postural Muscles

Figure 6: The anti-gravity bones

Figure 7: The otolith organs
Figure 8: Outside of a TTD.

Figure 9: Dome device.

Figure 10: Astronaut using RED.

Figure 11: Astronaut using CEVIS.

Figure 12: Astronaut using TVIS.


Emulsions and Support Structures for Personal Care Products

Chantel Sloan
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Dr. Scott T. Massey
Abstract:

The purpose of this paper is to discuss the different types of processes used to create and maintain personal care products which include emulsions and colloids, suspending body wash bases and physical matrix formations in liquids as well as the development of SiO₂. Emulsions and colloids allow for the mixture of different solid, liquid, and gas phases that would otherwise be immiscible. Suspending body wash bases allow less dense particles the ability to remain suspended in a more dense liquid. SiO₂ creates a physical matrix formation to provide a structure to hold solids in a liquid phase. These techniques provide the means to produce more useful and creative personal care products as well as other products in other industries.

Introduction:

*Chemistry, the tenth edition*, defines a suspension as a heterogeneous mixture in which solute particles settle out after mixing with a solvent phase. For example, when sand is stirred into water, a colloid is formed. The suspended particles, or dispersed phase, are suspended in the solvent phase, or dispersing medium. The particles of the dispersed phase are so small that settling is negligible. They are large enough; however, to scatter light as it passes through the colloid, making the mixture appear cloudy or even opaque. All combinations of solids, liquids and gasses can form colloids. They can all act as the dispersed, solute-like phase or the dispersing, solvent-like medium. Some examples of solids with solids include steel, colored gems and reinforced rubber. Some examples of liquids with solids include cheese, butter and jellies. Shaving cream and whipping cream are examples of a gas acting as the dispersed phase. Gasses can even act as the dispersing medium like smoke which is a solid dispersed, and fog, mist or clouds which are liquids dispersed in a gas. Mixtures will form a solution, a colloidal dispersion, or a suspension depending on the size of the solute-like particles as well as the solubility and miscibility.

Much of chemistry of everyday life is the chemistry of colloids. Because colloid particles are so finely divided, they have a tremendously high total surface area in relation to their volume. Atoms on the surface of a colloidal particle are bonded only to other atoms of the particle on and below the surface. These atoms interact with whatever comes in contact with the surface. Colloidal particles often adsorb ions or other charged particles, as well as gases and liquids. The process of adsorption involves adhesion of any such species onto the surfaces of particles.

Colloids are classified as hydrophilic (“water loving”) or hydrophobic (“water hating”) based on the surface characteristics of the dispersed particles. Hydrophilic colloids form hydrophilic sols (solid dispersed in a liquid).

Hydrophobic colloids cannot exist in polar solvents without the presence of emulsifying agents, or emulsifiers. These agents coat the particles of the dispersed phase to prevent their coagulation.
Solid soaps are usually sodium salts of long-chain organic acids called fatty acids. They have a polar “head” and nonpolar “hydrocarbon tail.” Sodium stearate is typical of the anions in soaps. They have a polar carboxylate head and a long nonpolar tail. The head of the stearate ion is compatible with water and the hydrocarbon tail is compatible with oil and grease. Groups of such ions can be dispersed in water because they form micelles. Their “water-insoluble” nonpolar tails orient into the interior of a micelle and their polar heads point to the outside where they interact with polar water molecules. It is often called a surfactant, “surface-active agent” meaning it has the ability to suspend and wash away oil and grease.

This information is also shared by Tharwat F. Tadros in Emulsion Science and Technology:\(^2\) A General Introduction. He explains in greater detail the different kinds of emulsions and the problems with sustaining an emulsion over time. He states that emulsions are a class of disperse systems consisting of two immiscible liquids. The liquid droplets (the disperse phase) are dispersed in a liquid medium (the continuous phase) Several classes of emulsion may be distinguished, namely oil-in-water (O/W), water-in-oil (W/O) and oil-in oil (O/O). In order to disperse two immiscible liquids, a third component is required, the emulsifier. Emulsions may be classified according to the nature of the emulsifier or the structure of the system.

Interaction energies:

Tadros\(^3\) explains that there are three main interaction energies (forces) between emulsion droplets. The first force is the Van der Waals attraction between atoms or molecules which include three different types: 1 dipole-dipole (Keesom), 2 dipole-induced dipole (Debye interactions) and 3 London dispersion interactions. The forces for the first two are large but they
tend to cancel due to the different orientations of the dipoles. Thus the most important interactions are London dispersion interactions, which arise from charge fluctuations. Tadros references Hamaker that suggested that the London dispersion interactions between atoms or molecules in macroscopic bodies (such as emulsion droplets) could be added, and this would result in a strong van der Waals attraction, particularly at close distances of separation between the droplets.

Repulsive Force:

In order to counteract the van der Walls attraction, it is necessary to create a repulsive force. The two main types of repulsion can be distinguished depending on the nature of the emulsifier used: electrostatic, which occurs due to the creation of double layers; and steric, which occurs due to the presence of adsorbed surfactant or polymer layers. When charged colloidal particles, in dispersion, approach each other the repulsion will occur.

Steric repulsion is produced by using nonionic surfactants or polymers. The thick hydrophilic chains produce repulsion similar to the actions of Sodium stearate as explained earlier.

In order to prepare an emulsion, oil, water, a surfactant and energy are required. Surface tension is positive, the energy needed to expand the surface is large and positive, and the total energy needed to form the emulsion is positive and thus the formation is nonspontaneous to produce the droplets. To form large droplets, as is the case for macroemulsions, high-speed stirrers are sufficient to produce the emulsion. In contrast, the formation of small drops requires large amounts of surfactant and/or energy. In order for a drop to be broken up into smaller droplets it must be strongly deformed. Consequently, the stress needed to deform the drop is higher for a smaller drop. Since the stress is generally transmitted by the surrounding liquid via agitation, higher stresses require a more vigorous agitation, and hence more energy is needed to produce smaller drops.

Surfactants:

Surfactants\(^3\) play a major role in the formation of emulsions. By lowering the interfacial tension, the stress required to break up a drop is reduced. Surfactants also prevent the coalescence of newly formed drops. During the emulsification process, the breakup of the droplets, adsorption of the surfactants and droplet collision occur numerous times, and the time scale of each process is very short, typically one microsecond. In all methods, there are forces that can be either frictional (mostly viscous) or internal. Viscous forces cause shear stresses to act on the interface between the droplets and the continuous phase. With each method, one essential variable is the intensity of the forces acting, thus the viscous stress. This viscosity plays an important role in the break-up of droplets- that is, the higher the viscosity, the greater the time taken to deform a drop.

According to Brookfield\(^4\), the suppliers of the viscometers used in the personal care lab, viscosity is a principal parameter when any flow measurements of fluids, such as liquids, semi-solids,
gases and even solids are made. Brookfield deals with liquids and semi-solids. Viscosity is the measure of the internal friction of a fluid. This friction becomes apparent when a layer of fluid is made to move in relation to another layer. The greater the friction, the greater the amount of force required to cause this movement, which is called shear. Shearing occurs whenever the fluid is physically moved or distributed as in pouring, spreading, spraying, mixing etc. the highly viscous fluids, therefore, require more force to move than less viscous materials. Viscosity measurements are made in conjunction with product quality and efficiency. Anyone involved with flow characterization, in research or development, quality control or fluid transfer, at one time or another gets involved with some type of viscosity measurement.

Breakdown of emulsions:

Tadros discusses the creation of emulsions as well as the contributing factors that break down the emulsions over time. These include but are not limited to the particle size distribution and the density difference between the droplets and the medium. It also involves the magnitude of the attractive versus repulsive forces. Various breakdown processes include creaming/sedimentation, flocculation, Ostwald ripening, coalescence, and phase inversion which Tadros defines and explains.

Creaming/sedimentation:

Creaming and sedimentation results from external forces, usually gravitational or centrifugal, exceed the thermal motion of the droplets. A concentration gradient builds up in the system and the droplets form a close-packed array at the top or bottom of the system and the remainder of the volume occupied by the continuous liquid phase.
Flocculation:

This refers to the aggregation of the droplets without any change in the primary droplet size into larger units. This is the result of the van der Waals attractions which are universal with disperse systems. Flocculation occurs where there is not enough repulsion to keep the droplets apart at distances where the van der Walls attraction is weak. Flocculation may be either strong, or weak depending on the magnitude of the attractive energy involved.

Ostwald Ripening:

Ostwald Ripening is the result of finite solubility of the liquid phases. Liquids are referred to as being immiscible. Emulsions are usually polydisperse and the smaller droplets will have a greater solubility when compared to larger droplets. With time, the smaller droplets dissolve and their molecules diffuse to the bulk and become deposited on the larger droplets. With time the droplet size distribution shifts to larger values.

Coalescence:

This process refers to the thinning and disruption of the liquid film between the droplets. The result is that two or more droplets form larger droplets. The limiting case for coalescence is the complete separation of the emulsion into two distinct liquid phases. The driving force for coalescence is the surface fluctuations which results in a close approach of the droplets and a prevention of their separation due to van der Waals forces.

Phase Inversion:

Phase Inversion refers to the process where there will be an exchange between the disperse phase and the medium. In many cases, phase inversion passes through a transition whereby multiple emulsions are produced.

Applications in the Lab:

The practical applications of these processes include lotions, suspending body wash bases, and body scrubs. Lotions and body wash bases have been used extensively in the research and development lab over personal care in Scottsdale, but body scrubs are new to their product line.

Lotions are made by mixing separate water and oil phases that are heated, combined, and then emulsified with a high shear emulsifier.
Suspending body wash bases are made to be more viscous to support the suspended particles in the different products including body washes. Currently a new body wash formula is being tested that contains diamond powder to create a more pampering product. However, the diamond power does not produce any visual effects and therefore mica is also added to create a visually stimulating product. The mica is less dense than the suspending body wash base and remains dispersed throughout the viscous base. This product does not require a high sheer emulsion process and can be mixed with the general mixtures in the lab.

The body scrub is the newest addition to the product line and is currently being tested in the lab as well as in house testing and national testing. This product has been researched by the scientists and also compared to current body scrubs on the market. Isil Kariyan, PhD⁵, Senior Scientist at Henkel explains that the solid stabilization agent in the body scrub includes silicon dioxide that is mixed at high speeds and then emulsified to produce a physical lattice, or matrix structure to support the salt and oil and reduce their separation. According to Evonik Industries⁶, there are current trends and hurdles involved in producing new materials. These trends include finding new raw materials that are derived naturally. Silica⁷ is a commonly occurring compound in nature. Various crystalline and noncrystalline silica minerals of inorganic and biogenic origin are known. Depending on temperature, pressure, composition of the precursor phases etc., several
different crystalline modifications are formed. Silica occurs as meter-sized quartz crystals or as amorphous masses made up of submicroscopic crystallites having different microstructures or growth fabrics. Both natural and synthetic silica powders are used as fillers. Under exposure to oxygen, a silicon surface oxidizes to form silicon dioxide (SiO₂). Thermal oxidation of silicon is easily achieved by heating the substrate to temperatures typically in the range of 900-1200 degrees Celsius. The atmosphere in the furnace where oxidation takes place can either contain pure oxygen or water vapor. Both of these molecules diffuse easily through the growing of SiO₂ layer at these high temperatures. Oxygen arriving at the silicon surface can then combine with the silicon to form silicon dioxide. The chemical reactions that take place are either “dry oxidation” \( \text{Si} + \text{O}_2 \rightarrow \text{SiO}_2 \) or the “wet oxidation” \( \text{Si} + 2\text{H}_2\text{O} \rightarrow \text{SiO}_2 + 2\text{H}_2 \).

The development of this body scrub has seen some changes in the formula including different amounts or raw materials as well as the order of addition of these materials. For example, polysorbate, is used to solubilize the water based dyes and fragrances into the oil based product. Isil Kayiran, PhD found that the addition order of the polysorbate and the silica does increase the matrix structure to support the oil and salt solids. There have also been adjustments based on the feedback from the in house testing. Some of the formulas were found to be too drying or too abrasive. The current national testing includes the formula picked by the in house majority. There have been several batches made to find the optimal formula, desired color and best fragrance for the product that will be launched in 2015.
Phase separation improved and color development changing

Current body scrub color, fragrance and formula for National testing
Preparations for the National testing

Conclusion:

Chemical processes such as emulsion, suspension, and silicon dioxide formation, as well as physical processes such as using silicon dioxide to form a lattice/matrix structure are procedures that have been developed over time and continue to undergo improvements to produce trendy new products as well as useful products. The personal care industry has benefited greatly from these developments as well as other industries and will continue to benefit from their many diverse applications in the scientific community as new discoveries emerge. The body scrub that is still undergoing experiments and improvements will be a nice addition to the personal care line at Henkel in 2015 after the experimental process is complete and the optimal formula, color, fragrance, and packaging is chosen. It has been an amazing experience to observe and be a part of the development of this product and I look forward to the new products that will benefit from what we have learned.
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A lot of people have had the fantasy of one day stepping foot on the beautiful planet Mars, and thanks to research it has been discovered due to the finding of water particles, life on Mars may be possible. Most people, including me are amazed at the fact that there is even a small chance of life on another planet. I have always been the kind of person that wonders if there are other planets out there that we are not able to see that have life on them. So far we have only been able to step foot on the moon, I say that so calmly but that really amazes me. The fact that we have come so far that we are even able to do that just means that eventually in the future there will be even more great discoveries and inventions. The next step for astronauts is stepping foot on Mars and actually seeing what it is like for themselves.

Mars is a lot different than our earth; the characteristics are different so some astronomers have a hard time understanding how there could be life on Mars. On the other hand, there are some astronomers that believe otherwise and believe that it is possible for there to be life on Mars. Most people think that living on the moon would be more realistic but that isn’t true at all. The moon also differs from our earth and has a lot of characteristics that wouldn’t allow life on the planet, (Smith 38). Living on Mars would be very difficult, but possible. There would be a lot of negatives that come out of living on Mars, but there are also a lot of negatives that come out of living on Earth too. Our earth was not made for us to just destroy it. Our environment is getting worse and worse and there are more and more people. Our earth was not designed for as much people as predicted to be in a few thousand years. Earth has everything provided for humans, humans are adjusted to living the way earth was
designed. If there was life form on Mars, the people (or creatures) would just have to grow accustomed to the way Mars is and then there could be life, (Cukavac 6).

Scientists have discovered that a meteorite from Mars that was found in Antarctica in 1984 may contain the remnants of biological matter on it, (Rogers 56). Though the findings are not conclusive they are the first signs of possible life in the universe outside of Earth. The fact that we are even talking, let alone thinking, about life on another planet is just unbelievable. The scientists who discovered this were just as amazed as I am. No one ever thinks that anything like this could ever happen, but it is happening. Since we have so many new technology to be able to send cameras in space and look at planets such as Mars, we are able to discover a lot more than before. Without all the new technology we wouldn’t be where we are today and we wouldn’t have discovered what we have.

A robotic planetary geologist landed on Mars August 2012. Preston shows a lot of research being done about how it would be possible to live on Mars. Once again, with all this technology we are able to find a lot more than we could without it. Placing a robotic planetary geologist on Mars is just another step closer to actually discovering either life on Mars or making it possible to live on Mars, (Kluger 20). Just thinking about it now, in the future, a few million years from now, what if it is possible to travel to Mars and just stay there for a while on a vacation? It is so incredible to think that could be possible and we are getting closer and closer to a great discovery.

The planet is known for its low atmospheric pressure and most of its water supply is frozen into a global ice table. The Phoenix lander launched by the U.S. National
Aeronautics and Space Administration (NASA) found the retrorockets had exposed a flat layer of bright ice. Fresh craters with fresh ice were also spotted by NASA's Mars Reconnaissance Orbiter (MRO), (Lakdawalla 22). This finding is very important for not only astronomers, but for regular people. If there really is ice on Mars then that could lead to an even bigger invention such as possible life form. The fact that we have only seen the “ice” just based off pictures doesn’t necessarily mean it is what we think it is. It could be something completely opposite of what we think it is or it could be exactly what we think it is. The truth is, we will never know until we are able to get people up on Mars to check it out themselves. That is the only way for us to figure out if it is possible for life on Mars. If we are one day able to get people on Mars, then that will get us even closer to finding a way for life to be possible on the planet.

Dennis Barnes describes an unusual event that happened on Mars recently. A shield rock meteor landed on Mars and normally would make a huge impact in the planet but seemed as if it was lightly placed there, (Barnes 34). This is quite unusual to me and I bet to others as well. I have always been very amazed with our solar system and I do believe that is possible that there are other life forms out there. It just seems very odd that a shield rock was just lightly placed down as if someone or something stopped the impact from being as great as it should be. If our world had a shield rock coming at us we would do anything we could to make the impact not as huge as it should be. That may be what happened. The theory is that someone or something saw this shield rock coming at their planet and they did anything they could to protect it and just lightly
placed the shield rock down so it didn’t do any damage. Obviously, this sounds crazy ridiculous but there are random theories going around.

Mars is an incredible planet, just like our earth. Living on Mars is possible, but won’t be easy. But who said living on earth was easy? There are going to be a lot of negatives coming out of living on Mars, but then again the positives will always outweigh the negatives. If we get the chance to travel to Mars and figure out if life form is possible on Mars that would just be an incredible experience for everyone. If it were possible to just travel to Mars on a vacation then we would only be traveling over the world, but we would be traveling over the solar system.
Work Cited


Vehicle Crumple Zones: Life Savers

Katie Snead

17 April 2014

PHY 111 (TR)

Dr. Casey Durandet
Abstract:

The further understanding of physics plays a major role in safety advances in order to keep an increasing number of people alive each year. Safety features in vehicles have been around since the automobile first began to become a necessity for all rather than an accessory for the rich; however, more advanced features have only began showing within the past half century or so. This project involves the ins and outs of crumple zones among other vehicle safety topics and their relation to the science of physics.

Introduction/Background:

Safety features in vehicles have been around since the age of the automobile first began; however, more advanced features have only began showing within the past half century or so. The further understanding of physics plays a major role in these safety advances in order to keep an increasing number of people alive each year. One can literally find the science of physics within nearly all aspects of life, but especially within the important field of vehicular safety. There are hundreds of different criterions placed within vehicles before they can even hit the road, some are never thought about while others are often needed. Safety features and other designs are constantly changing with new laws and increased pressure from citizens around the world for safer means of transportation.

Definitions\textsuperscript{1,2}:

Distance (d): the space from one point to another, usually measured in meters

Time (t): a measurable period, usually measured in seconds

Velocity (v): the rate in which a position changes, usually measured in meters per second
Momentum (p): how much motion an object has

Newton’s 1st Law ($\sum F_x=0$, $\sum F_y=0$): Law of inertia; an object at rest tends to stay at rest while an object in motion tends to stay in motion

Inertia: the tendency for an object to continue in the same state of motion

Newton’s 2nd Law ($\sum F_x=ma_x$, $\sum F_y=ma_y$): Law of Force; the acceleration of an object is directly related to the force acting upon it

Force (F): the push or pull on an object

Newton’s 3rd Law ($F_{12}=-F_{21}$): Law of Action/Reaction; every action has an equal and opposite reaction

Energy (E): what is needed for transportation and heating

Kinetic Energy (KE): energy associated with motion

Potential Energy (PE): associated with relative position

Crumple Zone: Also referred to as crush space or controlled deformation, this is the area of a vehicle that is designed to bend and deform when impacted in order to keep the passenger compartment intact.

**History and Evolution of Crumple Zones:**

In the 1950’s, automakers started to crack down on trying to figure out how to use the structure of their vehicles to absorb kinetic energy, but the struggle had just begun. It was difficult to figure out the correct characteristics to allow a vehicle to absorb a collision’s energy while not crushing too much and impacting the occupant areas. This paradox stunted the brains of many engineers until a Hungarian-born man, Bela Barenyi, developed the first “crumple zone” in 1952 which segmented vehicles into three parts: a crumple zone in the front and rear as well as the passenger area, called the transition.
These “crumple zones” were built with strategic weak spots in order to deform and allow the kinetic energy to be transformed into heat before reaching the passenger compartment. This spark of pure genius ignited the vehicular safety revolution that was set in full motion in the mid-1960’s when the auto industry began truly being pressured from both consumer advocates and government regulators. Crumple zones among other fundamental safety changes were being introduced into vehicles that, before, were practically bullets the size of a boat flying down increasingly populated roadways. The Insurance Institute for Highway Safety (IIHS) began testing frontal-impact crashes in 1995 and has exploded since. The popularity of IIHS’ results helped their quick expansion to include side-impact tests in 2003, then rear-impact tests in 2004.

Present Time Crumple Zones:

Crumple zones have surely evolved over the years but the concepts are still the same. The main area of crush space within vehicles today is in the front. Front-end collisions are typically the safest of collisions since the most space to deform is found in the front engine area (Marine, 2014). The entire front of a vehicle is designed to bend and crumple as force is applied in order to keep all deformation and energy from a crash’s inertia away from the occupant area. This frontal crush space minimizes the force applied on the passengers in order to also minimize injury. Other areas of a vehicle follow the same aspects, however, the distance between the area of impact and the passenger compartment is minimal.

Italy’s premier luxury car company, Pininfarina, who collaborated to build the design for some of the most attractive vehicles to this day such as the Masarati and Ferrari, tried to take the safety of cars to the next level with their concept car: Nido.
Nido was designed to maximize safety without compromising attractiveness. They used the natural functionality of honeycombs as energy absorbers to act as the crumple zone without having to have a large amount of actual space to crumple.

**Current Safety Laws and Regulations:**

There are hundreds of safety standards in place in order to keep the occupants as safe as can be. Unfortunately, these standards only cover vehicles going speeds of up to 35mph; a large majority of crashes occur in these lower speed ranges: 25-35mph. There are laws to cover how much force the roof of the vehicle must be able to handle without caving in, seatbelt stability and handling requirements and even standards for side-impact protection even though there is little open space for the sides of vehicles to deform before entering into the passenger compartment. These standards are extremely strict and every vehicle must pass each of the tests before it is able to go to market.

**The Physics Behind and Testing of Crumple Zones:**

The true miracle behind these deformation zones throughout everyday vehicles is the actual science behind it. None of the safety features within our vehicles today would be possible without the help of hard working physicists and engineers all over the world with a true desire to make everything safer for everyone. Crumple zones are built to deform in very specified places in order to keep the occupants safe, but when you look at the actual outcome of a crash, it does not seem very controlled.

There are countless different tests that can be run on any given vehicle; from bicycles to semi trucks, tests are ran throughout the year to find better means of safety. These tests are, by no means, easy or simple due to the fact that collisions are so random and there are quite literally thousands of ways vehicles can collide. NHTSA, the IIHS and
even privately owned companies are always trying to figure out ways to improve their testing methods since, although the ones currently available are not terrible, they can always be improved.

**Minimizing Occupant Injury:**

Crash-avoidance technology seems to be one of the main focuses with some engineering companies these days. From adaptive cruise control to anti-lock breaks and electronic stability control, the automotive industry is looking for even more ways to improve the safety of their vehicles. Engineers from Mercedes, Jaguar, Lexus and Infinity have developed a technology called “adaptive cruise control” where radar is able to detect the flow of external traffic in order to slow the car down when traffic becomes too close. This advance can definitely help those from getting caught in the moment with cruise control, but can also be easily taken advantage of when one falls asleep behind the wheel or even takes their focus off of the road and on some other task that otherwise would be put off until the car is not in use. Unfortunately human behavior can never truly be predicted.

Additionally, advancements have been made with vehicle’s braking mechanisms so that they do not lock when overly exerted. Nowadays, this technology is seen within virtually all vehicles because the popularity of the results was so exhilarating. Furthermore, advancements with braking systems to develop electronic stability control. Electronic stability control (ESC) is looked at as one of the “most promising advances in crash avoidance” yet not seen in many vehicles as standard features but rather additional options.
Another safety feature that has become a very standardized option yet is seldom thought about in one’s day-to-day life is a safety feature that is also constantly improving: airbags. Airbags are one of the most efficient ways to minimize occupant injury by both increasing the time and decreasing the force. Airbags act much like crumple zones do where they are built to expand but then crumple as you rapidly move away from your seat in order to keep you from simply slamming into the steering wheel or dashboard. Engineers understand that, as proven with Newton’s 1st Law, a body in motion tends to stay in motion to the point where when you are hit your body wants to keep moving forwards even though your car no longer is.

Furthermore, crash test dummies have been in the picture of testing the severity of collisions since early on. These dummies are placed in vehicles to allow the analysts to see exactly how humans would be thrown around in a vehicle from the force applied by different impacts (Marine, 2014). Crash test dummies spare no expense, with sensors all over their body to know exactly how humans would be hurt.

IIHS and Their Impact on Vehicle Safety:

The Insurance Institute for Highway Safety (IIHS) has always had a dramatic impact on the way vehicles are structured. As noted above, there are only safety laws and regulations in place for vehicles moving up to 35mph; however, the IIHS performs tests on all vehicles and then compares different makes and models and their ability to withstand higher levels of both speed and force than laws currently cover.

Manufacturers, although ensuring full compliance with the basic laws, want to go above and beyond with the safety of their vehicle in order to be more widely accepted and recognized by the general public. The IIHS has the financial ability to conduct these
tests and then releases their data results to the public with safety ratings and even awards or “top picks”. Manufacturers such as Subaru and Volkswagen have gotten to the point where their commercials indicate when they are an “IIHS Top Safety Pick” and it truly does seem to improve sales. When parents are looking for a vehicle for their teenager, they want the safest vehicles around; a vehicle being deemed a “Top Safety Pick” is definitely looked at as a golden star on its’ report cards.

**Potential Future of Crumple Zones and Passenger Safety:**

There are millions of different ideas floating around about what could be the next big thing in vehicle safety, but the ones that seem most hopeful are the ones that will be mentioned. A more advanced rollover prevention method, for example, is a focus that is often forgotten about. There is already ESC in place in many vehicles, as well as some laws about the stability of a roof, but the tests performed are hard to analyze completely because of the unpredictability of rollover crashes. A testing site can test a vehicle with the same conditions five times and get 5 different results; a vehicle’s personality while in a tumbling formation is ever changing and nearly impossible to duplicate perfectly (Marine, 2014).

Another topic that is often mulled over is increasing the amount of driving computers are doing to minimize driving done by humans. Some vehicles can already park themselves, so some ask engineers to take it to the next level and have computers drive the vehicles completely. Testing on this has already started years ago by companies like GOOGLE but that news left the media about as quickly as it entered.

Additionally, some believe that advancements in Hybrid and fully electric vehicles can still be made. Even with the Chevy Volt coming out as a virtually
completely electric until the electricity runs out and it can switch to gas as a backup source. There are still plenty of improvements that can be made such as increasing the longevity of the electricity being used. Also, the batteries in these so-called “wonderful” vehicles are also much more dangerous to, both, impact and dispose of (Marine, 2014). The chemicals used can be unpredictable when exposed to heat or force from a collision; these unpredictable variants can even potentially cause explosions when all forces are acting upon it at the correct times.

**Conclusion:**

Crumple zones are amazing, but they would not even exist without the great minds of physicists. It is truly amazing how much technology goes behind each of the experiments and tests performed in order to increase safety; however, I do believe that more can be done. After growing older and hearing about all the odd experiments that our tax money goes to, I definitely believe that more should go to legitimate testing centers who’s main priority is finding safer ways of building vehicles. With the size of the lot that Exponent sits on, they have so much potential to be one of the best testing centers in the United States, let alone the world, if they had enough money to build bigger and better testing mechanisms and devices. Car companies all over the world are always competing with each other to be the best car on the road, but if they worked together more rather than keeping secrets, the advancements in vehicles can rapidly increase.

Furthermore, safety regulations need to be mandated for highway speeds. Even though a majority of collisions happen at the lower, rural road speeds of 35-40 miles per hour, the more intense and deadly crashes happen when vehicles are going upwards of 70-75 miles per hour. Micky Marine said that he does not see any regulations coming for
those speeds any time soon because it is much harder to have a positive outcome with such high speeds, but with the growing population and the increasing need to travel for work, I believe it is necessary to keep roadways safe.
Fig. 1: NHTSA safety regulation for roof crush resistance during rollover crash

Fig. 2: Exponent crash dummy with wiring exposed
Bibliography


New Stable Stoichiometries in Chemistry Under High Pressures

Sarah Soaf

Dr. Massey
Chemistry 152
4/14/2014
Abstract

This paper reviews the recent research of possible chemical bondings, and crystal structures. Through the application of high pressures and controlled conditions, once unheard of chemical species have been produced. With new computer applications able to predict stable compounds and their structures, chemists will have the ability to create new species with exotic properties. This paper will discuss these high pressure species and how they improve understanding and research in a plethora of fields, including planetary physics. Including new understanding of metallized hydrogen in planets, and other high pressure species that once had no explanation. Many elements and compounds that were believed to be fully understood under normal conditions have undergone surprising changes under pressure. Calcium, a metal at room temperature, becomes transparent at high pressure. NaCl, basic table salt, in combination with a little more sodium and under high pressure, transforms into a two-dimensional conductor. Also new carbon allotropes that range from functional to beautiful, the superconductive abilities of many elements under high pressure, and USPEX a revolutionary code that can predict the structure of complicated crystals.

Introduction

Science is constantly evolving. While new discoveries are made in science every day, it is not very often that the basic rules taught to us in school change. Under high pressure and temperature everything assumed about chemistry no longer applies. With these conditions difficult to recreate within the lab, understanding the behavior of elements under high pressure largely remained misunderstood. With the ability of USPEX to determine theoretical stability even in high pressures, researchers have found chemical species that defy the basic rules of chemical bonding. Research in this area has been slow since these conditions are difficult to produce in the lab, especially in large molecules where there is a miniscule possibility of, stumbling upon the correct conditions. However, with these new computational methods efficiency will increase exponentially and so will understanding of high pressure chemistry. These changes will produce new findings and serve as the missing puzzle piece in research for years to come.

Body

In 1991, an algorithm for predicting molecular structures was produced. This algorithm which factors in variables such as hydrophobic and polar residues, can accurately predict minimum energy levels of heteropolymers and a variety of macromolecules. This understanding of the structure of proteins and amino acids allowed for extreme growth in related biological fields. While able to calculate the angle of every bond, and torsion in polymers, crystalline structure prediction eluded the scientific community until recently. USPEX (Universal Structure Predictor: Evolutionary Xtallography) is a hybrid evolutionary algorithm using optimization and the inverse relationships that exist within a crystal, to determine factors such as; intrinsic dimensionality, distance distribution, and variance of distribution. Evolutionary algorithms hold true to Darwinistic values, such as survival of the fittest, and hybridization through mutation, genetic heredity, etc. This is encouraged through controlled permutations, and lattice mutations.
Researchers can see areas of significance by locating global and local minima. These global minima signify stable species with the lowest free energy. With this computational method a crystalline structures most stable form can be predicted through its chemical composition. Even more impressive is that once this structure is found, scientists are also able to predict properties and behaviors of the structures. So far as to being able to see which stable structures are densest, which structures are superconductors, and which have properties we don’t quite yet understand. This is especially useful when studying crystals under extreme conditions, i.e. high pressure, high temperature. Before, these structures were most often experimentally determined, with few useful algorithms existing; the development of USPEX will expedite the search for new materials with highly desired properties. By showing researchers important areas and prediction of crystals in extreme conditions, instead of experimenting to find these required variables, one experiment is all that is needed to confirm the data from the program. Though there are still problems that arise, especially in large multi-funneled systems or those with degrees of order above 300. This algorithm is constantly being improved upon and already shows higher accuracy and faster results.

Due to the negation of the basic rules of chemistry i.e., ionic bonding due to electronegativity differences, under high pressure, even the most basic compound can change. NaCl, or table salt, a compound only known to exist in a one to one ratio, shows stable compounds such as Na₃Cl (shown), and NaCl₇ with interesting electronic properties under high pressure. Once produced using a diamond anvil, for high pressure and high temperatures, in combination with excess Na/Cl, these compounds are thermodynamically stable and remain indefinitely. Na₃Cl is of particular interest because of its ability for two-dimensional
conductivity. With the NaCl layers acting as an insulator and the pure sodium layers acting as a conductor. Such systems are in high demand in fields like electrical engineering\(^6\). Another norm that is no longer valid under high pressure is the underactivity of noble gases. Xenon oxides were found to occur at pressures above 83 GPa showing that at high pressure xenon will lose its inertness. While scientists are still unable to explain why abundance of Xenon in theorized the atmosphere differs so greatly from the observed. They are now one step closer to solving the paradox, with this experiment proving that Xenon silicates theorized to exist in the mantle could not exist. Due to the high oxidation of the Xenon silicates and the substantial reducing power of metallized iron in the earth's mantle the Xenon compounds would not be stable and would be broken down into silicates and free Xenon\(^14\). Boron is one of the least understood chemicals around, so much so that its stable states have not yet been established. Considering that it was eventually made stable by forming a complex crystal structure of ionic bonds with only itself which is counterintuitive, this is not surprising. This occurs between the partially oppositely charged lattices of B\(_{12}\) and B\(_2\). Gamma-boron one allotrope of the substance is one of the 5-6 hardest materials to date\(^7\). This experiment successfully shows that elements can form complex ionic bond with themselves through the influence of many-body interactions\(^12\). Another Boron compound developed with promising contributions to science is Magnesium Borohydride, Mg (BH\(_4\))\(_2\) whose synthesis has been a work in progress. Through USPEX its stable structure was found and replicated. Important because of its 14.8% hydrogen capacity and the fact that it is so lightweight this material was sought out for the use of rocket fuel and so far, results support this application\(^13\). Phenomena such as these go against the basics of chemistry, showing the importance of continued research and growth in any topic, coupled with the ability to question one’s surroundings.

Not only does a compound's structure alter dramatically under high pressure conditions, its optical properties can also take a surprising change. Calcium experiences demetallization under pressure and becomes a superconductor at ~50 GPa. Not only that, but it has the highest Tc (superconductor transition temperature) of any element, being 25 K at ~161 GPa\(^8\). This chart shows the minimum required relationship between Tc to be considered a superconductor. Calcium also exhibits some interesting physical changes, at ambient conditions it exists as a metal, becoming black at around 130 GPa. The most amazing visual change of all occurs at about 200 GPa where calcium becomes a yellowish transparent material\(^6\).

Calcium isn’t the only element that becomes a superconductor under pressure many other elements were found to develop superconductive abilities at high pressures. Many compounds which are known insulators at ambient pressure become superconductors when pressure is increased.

While calcium experiences
demetallization under high pressure, researchers have found that the exact opposite is true in many other cases. In particular, hydrogen rich compounds can become effective superconductors at high pressure and evidence has shown can even experience metallization \(^{16}\). Metallization of hydrogen since theorized has been vehemently sought after, one such hypothesis of how to reduce the pressure needed for hydrogen’s metallization is the introduction of a tetravalent atom. Researchers found when looking at compounds of lithium and hydrogen through a range of pressures, in specific LiH\(_6\) or LiH\(_2\), they became both metallic and stable at pressures between ~100 and 165 GPa. The results of this experiment imply a possibility that hydrogen metallization could occur through electron transfer from an electropositive element, due to the sub lattice of H\(_2\) LiH\(_2\) being metal at ~100GPa when hydrogen by itself is not. Since we are currently not able to replicate the pressures theorized to be necessary for metallization of hydrogen, lowering the pressure of metallization through the introduction of a tetravalent atom is currently our best bet of seeing the behavior of metallized hydrogen \(^{16}\). This has been long sought because of its effect on planetary physics, including magnetic fields on some planets. A better understanding of metallized hydrogen would help in the determining of planetary models.

Carbon, the basic building block of all life, is one of the most studied elements. Serving as a perfect example of the relationship between structure of a compound and its properties, carbon allotropes are extremely diverse. Ranging from graphite whose layers of carbon gives graphite soft, malleable qualities. While the more complicated isometric crystalline structure of diamond, with atoms at all apices of the tetrahedron, is the densest and hardest material known to man \(^1\). The versatility of carbons allotropes leave new ones in high demand. New theorized allotropes HP3, tI12, and tP12 are denser than diamond and almost as hard. They are currently believed to have the ability to be synthesized through shock compression of amorphous carbon. These allotropes all have a higher refractivity than diamond as well, which will make for more lustrous and colorful stones. HP3 is theorized to be a semiconductor, and tP12 an insulator \(^{13}\).
One of the most promising contributions that USPEX and new understandings of high pressure chemistry will make is in the understanding of the formation of planets and their cores. Magnesium-Oxide, long thought to make up much of the planets interior and has a thermodynamically stable stoichiometric ratio of 1:1. With the discovery of MgO2 and Mg302 came the understanding that planets may be made up of compounds completely unknown to us. Since these magnesium-oxides are stable in high pressure and can resist the high reducing power of Fe below the earth’s mantle, it is logical to deduce that these compounds could play a substantial role in earth sized planets cores. Understanding of methane in gas giants like Uranus or Neptune has been stunted by the limited knowledge on methane’s phase charts. Metallized hydrogen and diamond would be the aforementioned theorized waste products in methane’s decay in planetary conditions. Since diamond is of higher density it should however be pulled through the planet by gravity, something was missing. C2H6 and C4H10 served to be the missing puzzle pieces, unlikely to sink, it was theorized that these could occur in abundance in Neptune’s ice layer. Samplings taken support this hypothesis. Understanding the properties of the chemicals that make up a planet's mantle helps us determine planetary properties such as seismic anisotropy and other geophysical forces. Seismic anisotropy was recently explained by exploring (Mg, Fe) SiO3 in its perovskite and post-perovskite structures.

**Conclusion**

Crystalline structure prediction now simple and concise in the form of a computer program, has allowed for recent research on crystalline structures, especially in extreme conditions has allowed for a deeper understanding of high pressure. What started as an algorithm to solve sciences inability to correctly predict the structure of a crystal has created limitless opportunities. With USPEX one was able to calculate conditions, properties, stabilities quickly and accurately. Using USPEX species that defied the very laws of chemistry were found. There were species discovered that violate the octet rule such as NaCl3. Compounds that formed with Xenon, showing that under high pressure noble gases can lose inertness. Organic two dimensional conductors long predicted were finally found, existing as crystalline structures with alternating layers of conductors and insulators. Stable states of Boron were found forming ionic bonds between lattices of Boron, supporting another theory that through multiple body interactions elements can form complicated systems forming ionic bonds only with themselves.
Many of these stated above go against the basic rules of bonding, going to show importance of never believing you’ve discovered everything to know about a certain topic. Also interesting to look at, is how an element will vary in different conditions. For example, Calcium goes through metallization after 50 GPa becoming a superconductor. It’s not only chemical properties that change but also physical. Calcium seen shifting from a black metallic substance, to a yellow transparent substance as pressure continues to build is a perfect example. This superconductor also has the highest superconducting transition temperature currently determined. Under high pressure a plethora of systems were found with super conductive properties. This suggests that every compound known to man undergoes exciting changes in high pressure temperatures and atmospheres. Carbon became even denser under high pressure, allotropes were found denser than diamond and with significantly higher refractivity, hinting at a beautiful, lustrous appearance. Now able to imitate and look at species under pressures similar to those in planetary cores things such as the decomposition of methane and never before seen stoichiometries of magnesium oxide help us build planetary models and give us a greater understanding of planets geophysical properties. High pressure chemistry not only tells us about the planets but can also help us get there with magnesium borohydride or Mg (BH₄)₂ long sought after for hydrogen storage i.e. rocket fuel, could help us go and see the effects of metallized hydrogen in gas giants ourselves.

Whether looking at Magnesium Oxide in Earth sized planet’s cores, methane waste products in gas giants, or simply reevaluating chemical combinations that could exist all around you. USPEX will speed up scientific progress in the coming years. Now able to look at chemistry in a whole new world, the discoveries made with this tool will be both exciting and groundbreaking. I once heard a Physicist say that his experiments will affect research that has not yet even been hypothesized. That the discoveries he makes could be the key to future research or cause research that may otherwise never have come to pass. One never knows the affects that their discoveries will have on the future of humanity and the future of science. Promoting critical thinkers who are able to continuously question and evaluate everything that they have been taught will allow for more discoveries like this. Innovation and creativity are key to humanities ability to reach the next frontier of science. One can only wonder what else is left to be discovered.
References

Cosmic Dust and its Part in the Universe

Alexandra E. Stoller

AST 112: Stars and Galaxies

Professor Jenny Weitz

Paradise Valley Community College

Spring 2014
Abstract

This research paper explores the detection, formation, and importance of cosmic dust in the Universe while paying specific attention to the Milky Way galaxy and Earth itself. The intention of this paper is simply to inform and help the reader understand what cosmic dust is and its part in the creation of objects found in the universe including stars, galaxies, planets, and even biological life forms.

Cosmic Dust

Cosmic dust can be most simply defined as fine particles of matter in space. Cosmic dust is composed of various elements such as hydrogen, helium, oxygen, carbon, and iron, all of which can be found in the human body. Cosmic dust is found in several parts of the universe in and outside of our galaxy. Cosmic dust is an essential part of the formation of all objects found in the universe and therefore one of the more important astronomical subjects that can be studied.

Detection

An important question when discussing any astronomical information is, how do we know? In this case we specifically ask; how is this dust detected? There are a few detection methods. The following is one of the most successful. The Herschel Space Observatory observed the dust properties of distant galaxies in the redshift range from 0.1 to 2.8, and local galaxies of the redshift range less than 0.1. Infrared luminosity and dust temperature of several galaxies were obtained from the spectral energy distribution of far-infrared flux densities found by special instruments onboard of Herschel (Hwang, 2010).
Another way to measure dust is with radio and plasma wave instruments. The high velocity impact of a cosmic dust particle creates a little crater on the spacecraft. The amount of small craters observed and the readings of the impacts recorded by the instruments indicate the size, velocity, electric charge and total amount of dust and the direct it is heading in the tested region (Belheouane, 2012).

Formation

Another important question to ask of cosmic dust is where does it come from? It is not completely clear where early dust in the universe came from. However, it is known by all who study astronomy that dust in space has existed since or maybe even before stars. All stars start as a cloud of gas and dust! Gravity collapses these clouds and the center becomes very hot and dense. After time the density and temperature reach a point where nuclear fusion can occur. Fusion is the combining of the heavier and lighter atoms, in this case hydrogen and helium. Gravity continues to try and collapse the forming star but the inner fusion pressure pushes outward allowing it to stay intact and expand, this process is known as star balancing. Eventually, after millions of years these stars become out of balance when hydrogen begins to run out. The helium left will expand until the star becomes a huge and cool star known as a Red Giant. A high-mass star, or a previously extremely hot gigantic blue star as it dies will continue to have some fusion in its core developing all sorts of new heavier elements including oxygen, carbon, sodium, neon, magnesium, silicon, sulfur, phosphorus, nickel and iron. Blue giants have a short life, and explode dramatically (Weitz, 2014). This explosion is known as a supernova. During a supernova explosion the contents of the star are ejected into space and either a neutron
star or a black hole is left behind. The ejected material is dust and gas. This left over dust and gas (hydrogen and helium) from several supernovae is scattered thinly through space. Small dust gatherings floating around in space are affectionately known as “cosmic dust bunnies.” These small “bunnies” sometimes can bind and expand to become large “clouds” (Freed, 2007). As the video *The Birth of a Star* explains, in some regions the hydrogen and helium atoms will lie close enough to one another so that they will pull together gradually one by one until a cloud is formed. If the cloud is big enough the process of star creation will repeat. By comparing the radial dust distributions derived from redshift observations of galaxies, such as Herschel did, simple analytical models of dust buildup can be created. These models indicate the shape, size, and location of the dust gatherings. Researchers Lars Mattsson and Anja C. Andersen’s observations of these models show that dust “gradients” or slopes are typically more common than the corresponding metallic gradients and that there is very little dust destruction, but significant interstellar dust growth for most of these galaxies. Mattsson and Andersen concluded that there is also evidence for non-stellar dust production, and very little evidence for dust destruction caused by supernova shock-waves. They found that dust is actually reprocessed by the shock waves. This means that the current estimated dust-to-metal ratios are incorrect and that these every day metals found all over our planet are more uncommon than anticipated.

**Examples**

Observations of incredibly large gatherings of cosmic dust that are well illuminated help us learn the most about what activities occur within dust collections. The most spectacular specimen of cosmic dust known commonly as The Pillars of Creation
can be found in the Eagle Nebula. This nebula is about 6,500 light-years away. Each pillar alone is several light-years long. Two major photographs of the pillars have been released, one by Hubble in 1995 this image was only of the visible light they admit. However, the second more recent image taken by ESA Herschel Space Observatory was taken in 2012. This new image was captured in infrared wavelengths which allow observing astronomers to see inside of the pillars. Furthermore, a new multi-energy X-ray image from ESA's XMM-Newton telescope shows hot young stars are responsible for creating the pillars (Dunbar, 2012). These iconic images are not only beautiful but help us understand the everlasting cycle of creation and destruction in our Universe. Another interesting example of cosmic dust behavior occurs in the Circinus galaxy. This galaxy is not only home to a large amount of dust but also to a super massive black hole. Very recently in March 2014 an international team of astronomical researchers in Germany have released their observations of the active Circinus Galaxy. They have obtained the clearest image ever taken of warm dust near a super massive black hole using the MIDI instrument at the Very Large Telescope Interferometer of the European Southern Observatory located in the Atacama Desert of Chile. The dust appears to be separated into two distinct components. The first is an inner "warped" disk and the second is a surrounding larger distribution. These findings refute the popular "dusty doughnut" configuration. The outer dust is gradually being pulled into the black hole. The matter spiraling into the black hole has become so hot and luminous that it outshines its entire galaxy. This leads to active galactic nuclei, which basically means enormous amounts of energy are being released due to the feeding of the super massive black hole. This discovery will change the current models of dust gatherings (For, 2012).
The Milky Way

The space dust found in our galaxy is more attainable but there are no indications that it is any different than the dust found in other galaxies. The dust present in the Milky Way galaxy today is believed to be produced in the envelopes of evolved low-mass stars though it is believed that core-collapsing supernovae that arose from early star generations were the main sources of cosmic dust in the early Universe (Mattsson, 2011). The Milky Way is a spiral galaxy. A spiral galaxy is made up of a bulge, disk, halo, arms and nearby globular clusters. Most interstellar matter/dust is found in the disk of our galaxy. Within this disk the dust and gas of our galaxy clumps together to form clouds. In fact, the dust obscuring the view of the bright bulged center is what indicates it is a spiral galaxy. The trade mark spiral arms are important star forming regions due to the pile up of interstellar material (Weitz, 2014).

Cosmic Dust on Earth

Many tons of dust grains, including samples of comets and asteroids, fall from space into the Earth's atmosphere each day. Once in the stratosphere cosmic dust and spacecraft debris join with terrestrial particles such as windborne desert dust, pollen grains, and volcanic ash just to name a few. All of the elements found in cosmic dust can be found on Earth and in the human body. The Earth was formed by particles in space or cosmic dust. Without these elements essential to our existence life could not be created.
Conclusion

Cosmic dust is an essential part of the formation of all objects found in the universe. As this paper suggests, it is probably the most important astronomical subject in understanding stars, galaxy, and planet formation.
References


Missions to Asteroids

SavannaSucanick

AST111

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Professor Weitz
Abstract

This paper gives an overview of the history of asteroids, the missions taken in the past and missions that will take place in the future that explore and observe asteroids, as well as facts about the asteroids in our universe. These missions have provided an immense amount of data. New information is being learned through every mission. The Dawn mission will be a focus point in this paper to show all details involved in these types of missions.

Asteroids have always been a part of our galaxy and now it is time to learn all we can from them, not only about asteroids in general but about our galaxy we live in. According to the Merriam-Webster dictionary an asteroid is, “any of the thousands of small rocky celestial bodies or small planets that circle around the sun and are mainly found between Mars and Jupiter”. Today when we look out into the solar system, we observe a near-steady state and, while there are periodicities and occasional collisions, averaged over millennia there is little discernible change in the system. When most people think of asteroids, we think of them breaking through Earth’s atmosphere and crashing into our planet. People’s perception about crashing into our planet automatically gives us a negative thought about these “giant rocks”. They caused fear during the Roman and Medieval times when they thought of asteroids as bad omens (Barucci, 2011). But today we have a better understanding of asteroids that used to bring such fear.

The history of asteroids is long, but according to Barucci (2011) in the past 100 years asteroids have become more than just star like points. In the past 25 years
spacecraft exploration began that opened the new doorway to new information. At first, asteroids or comets were thought to move in straight lines as thought by Johannes Kepler who had come up with the laws for planetary motion, when observing a certain comet (Barucci, 2011). Later, Edmond Halley soon found out that they in fact do not move in a straight line but move on an elongated ellipse (Barucci, 2011). Halley had observed the same comet that was observed by others including Kepler and by finding out that they move in this ellipse he predicted it would be back and that they also orbit around the sun. We have learned so much from not only studying asteroids from Earth but from within space by getting up close to these planet like objects.

Asteroids come in many different shapes and sizes that have their own characteristics. Although asteroids appear to be just rock there is so much more to them. The self-gravitation of asteroids, however immensely small, is important to their evolution (Asphaug, 2004). In the paper by Asphaug (2004), he states, “Most are very porous, spin rapidly, and are irregular in shape, suggesting a tumultuous history.” Asteroids are made up of the pieces of the super nova which began when the universe began. They share the same history of our solar system. Fred Whipple proposed that comet nuclei are made of ices implanted with dust that create a blanket of gas and dust around the asteroid when released from the heat of the sun (Barucci, 2011). So the process of melting and hardening again has made up the shapes of asteroids. Also colliding with other objects in space have formed asteroids. Within asteroids are chemicals, cosmic dust, and other matter that could have played a major role in the development of life on Earth (Barucci, 2011).
Space missions involving the study and understanding of asteroids have been revolutionary in the information uncovered during missions and have been providing an ever-growing amount of physical, chemical, mineralogical, and morphological data about asteroids in recent years” (Shevchenko, 2005). Without visiting the bodies that are the building blocks for the solar system, we can do very little to understand them. Space missions to asteroids advances our knowledge and data collection by more than 10 times. Performing and participating in actual space missions allows astronomers to study several hundred objects instead of just two or three objects at a time (Shevchenko, 2005). In 1992 scientists had gotten the first close-up view of an asteroid as the probe from the Galileo mission was on its way to Jupiter to capture images of Gaspra and Ida (Asphaug, 2004). Ever since this occurrence, interest in asteroids has changed and is making a huge impact on science and missions to take place in space. Dawn is one of the most well-known asteroid missions, I think, of all time that still is taking place.

“The Dawn spacecraft of the NASA space mission to asteroids Ceres and Vesta was launched in September 2007” (Lupishko, 2009). Why exactly were these two asteroids selected? Ceres and Vesta were the largest and most massive bodies of the main belt: they contain about 35% of its mass. Ceres and Vesta are the two biggest known asteroids in the asteroid belt. These asteroids are very different and much more massive from the rest of the asteroids that make the main belt their home. The purpose of this orbital mission is to study the shape, size, mass, composition, and magnetism of these asteroids.

The Dawn spacecraft launched successfully from Cape Canaveral, Florida in the year 2007 on September 27th. “After using Mars for gravitational acceleration in
February 2009, it should reach the vicinities of Vesta and Ceres in August 2011 and February 2015, respectively, having travelled over $4.8 \times 10^9$ km” (Lupishko, 2009). From the data obtained by the ground-based and, especially, HST observations, it is known that the shape and morphology of the surface of Vesta are completely different. The spacecraft spent a year at Vesta starting from July 16th, 2011 and then departed for Ceres on September 8th, 2012. “Never before has a spacecraft been designed to travel to another solar system body to orbit it, then to depart for a second body to undertake a new orbital exploration with the same instrumentation” (Russell, 2011). This is an evolutionary mission that will bring so much new information to the table.

The information that could be brought back could help in our understanding of the formation of the early solar system and even the asteroid belt itself. One could be rightly skeptical that bodies orbiting the Sun for 4.6 billion years could tell us very much about the events that occurred at the birth of the solar system. Just as we are curious about our human ancestry, we are curious about our planetary ancestry. We can gain insight into who we are and how we got to where we are from our genealogy. We can do the same with our planetological studies of these precursors to the Earth and her neighbors. The Dawn mission is therefore not just an exploration in space but also an exploration in time.

The Dawn spacecraft is equipped with many different devices in order to collect a variety of data. “The Dawn spacecraft carries a CCD camera (1024×1024 pixels) for imaging the surface, a spectrometer for mapping the surface in the visible and infrared (IR) ranges, a gamma/neutron spectrometer, a magnetometer, a gravimeter, and radar” (Lupishko, 2009). This high-tech gear will help make this mission a lot easier when
collecting the right data. This mission could be a game changer for sure. “The Dawn mission is therefore not just an exploration in space but also an exploration in time—a time machine that will help us to communicate with the events that occurred 4.6 billion years ago” (Russell, 2011). While it is in humankind’s psyche to explore, an undertaking like that of Dawn cannot take place without a well-defined set of scientific objectives or scientific questions that it will resolve. Now we wait for the return of the Dawn spacecraft in hopes of a brand new understanding of our vast universe and all that inhabit it.

Another ambitious asteroid mission is that of the Japanese spacecraft, Hayabusa, which made its way to Itokawa, a near-Earth asteroid that is 0.5 km in diameter (Asphaug, 2004). The Hayabusa soft landing mission was launched May 9th, 2003. The spacecraft made two different landings on the surface of the asteroid November 20th and the 26th in the year of 2005 that had successfully brought back samples to Earth (Yurimoto, 2012). It had actually ended up returning to Earth in Australia on June 13th, 2010, a long seven years later. In its return it retained more than 1,500 grains of rocky particles that were found on the surface of the asteroid. The preliminary examinations started from January 21st, 2011 that included X-ray CT analysis, X-ray diffraction analysis, petrology, mineral chemistry, oxygen isotope analysis, trace element analysis and noble gas analysis in determining that these particles are perfectly extraterrestrial material (Yurimoto, 2012). Even the littlest bit of particle can tell us so much about the solar system and the more we explore these asteroids, the more knowledge we gain.

Continuing missions like orbiters, rovers, soft or hard landings, and similar missions as to these shall continue to take place and hopefully even turn into man
missions. That will be the day. Although most observations of near-Earth asteroids have been made with satellites there has been 12 missions using spacecraft (Shevchenko, 2005). All the data that has been retrieved and observations made, both hold important data that will keep the motivation of carrying out more missions in the future. As of right now NASA has more missions to asteroids that will take place down the road and like the Dawn mission there are spacecraft’s yet to return with more important results. Asteroids are not meant to be feared but to be explored, observed, and studied for the purpose of pure knowledge if not to fulfill our curious minds about such vast objects in our solar system.
References


This article has valid information that is quite up to date from only a few years ago. The article presents factual information with what may also seem a bit of opinion because they give their understanding of the solar system and formation of the asteroid belt and seems completely unbiased. This information’s purpose is to inform the reader of the Dawn mission and of its finding of Vesta and Ceres. Russell is a professor at the University of California, Los Angeles in the Earth and Space Sciences department. Raymond attended the California Institution of Technology. This article is relevant to my topic and in incorporating this information I will increase my credibility.


This isn’t the most up to date information because this paper was written before the Dawn mission occurred and is based on the observations from Earth at the given time period. The presented information is all very factual and unbiased based on their research. The purpose of this paper is to inform the reader, who includes anyone interested in reading it, about progress in the study of Ceres and Vesta. Both of the authors have a high level of expertise based on the fact that they work in the astronomy departments at two different Universities. The information that is provided could give
extra facts that the previous article may not have included and it is also relevant to my topic.


This article is up to date and has some latest information from missions such as from the ESO Giotto and JAXA Hayabusa missions. This article was published in late year of 2011. The information within this article is factual based on the different missions talked about. The purpose of this article is to inform the reader of the chronological analysis of comet nuclei and asteroids from the missions mentioned previously. The authors seem to have a high level of expertise from working in observatories in France and Italy. The information will provide a unique contribution to my paper by adding information of the formation of asteroids. The information I will use in my paper is relevant to my topic.


This article was published in 2004 and doesn’t provide the most up to date information but gives me information to use on the background of asteroids and when they were first discovered. The information provides clear facts with his overview of someone else’s work. The purpose of this work is to inform while also entertaining the audience to encourage the knowledge of asteroids. The author, Asphaug, is in the department of Earth Sciences at the University of California providing is expertise with in his work.
The article is relevant to my topic because it talks about how missions to asteroids started.


The article shows most up to date information on the Hayabusa mission and its findings along with the hypothesis that meteorites are an asteroidal origin. The work is clear with information containing facts about the study and is bias free. The author’s purpose for the article is to inform the reader of his hypothesis and evidence supporting it. His expertise is in the natural history sciences at Hokkaido University in Japan. He showed his expertise through the knowledge he shared about a specific asteroid compared to meteorites. This information would add to the different characteristics about asteroids.


The currency of this article does not really matter because it is stating facts from all sorts of different missions that helped us gain knowledge about asteroids. The paper is precise and clear cut in order to help the reader to understand the material. The purpose of the paper is to inform the reader of different observations of asteroids and the missions that went along with is but also to maybe persuade the reader to be interested in knowing about asteroids. Shevchenko is a professor at a University in Ukraine and Mohamed is a professor at another University in Libya. They show their expertise through the knowledge they have in astronomy and physics. This article will benefit my paper by
providing specific information about spacecraft exploration of asteroids which is exactly what my topic is on.
Peyton Manning: The Physical Quarterback

Monica Thomas

Honors Physics 111, Section 16066
Dr. Casey Durandet
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Abstract

The topic of study researched in this paper discusses how the laws of physics factor into a football quarterback’s performance. The research divulged in this paper seeks to answer the questions of how the physical principles of velocity, acceleration, momentum, parabolic trajectory, and aerodynamics influence the level of performance a quarterback achieves. The findings on these fundamental concepts are then used to more specifically analyze Peyton Manning, the quarterback of the National Football League’s Denver Broncos, and correlate his quarterbacking abilities to physical properties. The goal of this research is to apply the conclusions drawn based on the physical study of Manning’s performance into a hypothesis of what awaits future quarterbacks and how their efficiency will be measured in terms of physical means.

The History of Football

The sport of football traces its roots back to England during the 1860’s. The games revolved around kicking a rounded ball and had little physical contact; this sport is now referred to by Americans as “soccer,” and was later organized into the Football Association of England in the year of 1863. In response to this non-aggressive, contactless game, Britain’s Rugby school deviated from the kicking that lay central at soccer’s dogma, and moved towards a more physically violent competition that involved carrying the ball as the main source of scoring points and determining the winners of each game. This new approach towards ball games carried over to the northeast of the United States, where football was still in its early stages and was run in a highly unorganized fashion throughout the few towns and schools that adopted it. Each town and school held different sets of rules that governed the game; one aspect of the game that ran consistently throughout these different groups was the setup of twelve men on each side and whose ultimate goal was to run the ball over the goal line and into their opponent’s end zones.

In the 1870’s, football became more nationally popularized as Yale University’s Walter Camp, deemed by many as the “godfather” of American football, sought to differentiate it from its close cousin rugby by putting stricter rules into place that imposed specific boundaries, roles and plays to be followed by all teams. The competitions between Oneida of Boston Common (the first organized American football club) and Harvard University’s football team introduced the excitement of the sport to America. The football rivalry that contested between Harvard and McGill University became well-known in 1874, and introduced the whole United States to what would soon become its ultimate athletic obsession. In 1880 and 1882, Camp’s committee designed the game into what it looks like today, as the game’s main focus turned to the relationship between the center and the quarterback at the line of scrimmage, the “down” system was put into effect and five-yard intervals became the measuring tool used by referees.

Although football had been brought into the United States and was steadily gaining participation and attention amongst citizens, few players actually made a name for themselves playing the sport professionally; actual games played between organized teams existed only in the states of Ohio and Pennsylvania. It wasn’t until the 1920’s that professional football actually emerged when the American Professional Football Association was established in Canton, Ohio.
This league was later renamed as the National Football League (NFL) in 1922, which is what it is known as today. In 1925, the NFL gained popularity as Chicago Bears halfback Harold “Red” Grange became the first megastar of the NFL who made a fortune off of all the publicity earned from endorsements. After struggling financially in the 1930’s due to the Great Depression, the NFL, led by commissioners Bert Bell and Alvin “Pete” Rozelle, battled against their new competitor in the American Football League (AFL), who lured in the University of Alabama’s famous quarterback (and eventual NFL Hall of Famer) Joe Namath to draw in spectators to play for the New York Jets. Eventually an agreement was reached between the two leagues, which merged them together in 1966; in 1967 the first AFL-NFL Super Bowl was held.

Throughout the NFL’s beginning decade of the 1970s, the league was dominated by teams that attacked opposing defenses with powerful running games and pounded opposing offenses with unmerciful defensive front sevens, as evidenced by the American Football Conference’s (AFC) Pittsburgh Steelers, the great football team of the decade who won four Super Bowl titles within those ten years. Heralded on the defensive side of the ball by defensive lineman “Mean” Joe Green and the rest of the “Steel Curtain” defense, the fear of God was instilled into quarterbacks, who handed off the big job of getting the ball into the opposing end zone to their running backs. Statistical data shows that the average 1970’s NFL team ran the ball 58% of the time and passed 42% of the time; in the 1960’s the average pass thrown by quarterbacks was 4.6 yards. League-wide, quarterbacks threw interceptions 6% more often than running backs who only fumbled about 3% of the time.

In the 1980’s, San Francisco 49er head coach Bill Walsh revolutionized the NFL offense and paved the way as to how the game of football is played in modern culture. Walsh created what is now known as the “West Coast Offense,” which moved its focus away from the running back and placed the fate of each game into the quarterback’s hands. His offense, still widely used today, consists of short, timed running routes for wide receivers that must be followed step-by-step and demands both precision and accuracy from a quarterback to deliver the ball safely into his receiver’s hands. Walsh created a system that gave the quarterback several different options to choose from while scanning the field in the pocket, with a primary receiver identified before the start of the play, and as time progressed and if different defensive coverages were being used, the quarterback could turn to a second, third, or fourth option to throw the ball to. This lessened the chances of the quarterback throwing an incompletion or interception, and its quickness confused defenses, leaving them behind as the opposing offense marched into the end zone. Walsh’s system resulted in four Super Bowl victories throughout the 1980’s for the 49ers, led by Hall of Fame quarterback Joe Montana.

The 1990’s only continued the shift away from the former running ways of the NFL, as the interception rates of quarterbacks fell from the former 6% of the 1970’s to a mere 3% throughout the 1990’s decade. By 1995, the chances of a quarterback throwing an interception and a running back fumbling the ball became equal. Throughout the 1990’s, the National Football Conference (NFC) continued to dominate, with the Dallas Cowboys capturing three Super Bowls under legendary coach Jimmy Johnson and Hall of Fame quarterback Troy.
Aikman. Walsh’s influence carried over to the 2000’s decade, as his protégé Bill Belichick took over as head coach for the New England Patriots and led them to three Super Bowl titles with superstar quarterback Tom Brady under center. During the year of 2005, statistics released revealed that quarterbacks throughout the entire NFL threw for a total of 16,430 passes, completed 59.5% of them with only 3.1% of them being intercepted, and had a cumulative total of 507 interceptions thrown league-wide\(^2\). The game of the quarterback had been born.

The Football

The first football was created in the mid-19th century, and was made from an inflated pig’s bladder (hence the nickname of “pigskin” given to the football today). However, these balls didn’t hold up properly, and manufacturers soon turned to leather and rubber, the materials used today. Because football was originally centered around kicking the ball, the balls were much more rounded when they first came about. However, as the late 1800’s approached and the game shifted towards throwing and running with the ball in hand, adjustments had to be made in order to make the ball easier to carry\(^3\).

In the early 1900’s, the forward pass became legal, and manufacturers were forced to change the composition of the football from its rounded, difficult-to-carry shape into a more elongated shape that fit into the player’s hands more easily. The size of the ball was reduced from 23 inches to 21.83 inches, and the nose was made pointier\(^3\).

An official NFL football today is known as the Wilson Model F1100. It’s been nicknamed “the Duke” in honor of Wellington “the Duke” Mara, the original founder/owner of the New York Football Giants. It carries the signature of NFL Commissioner Roger Goodell\(^3\). A football is modeled around its long axis of symmetry, and carries equal density on all sides. It weighs about 0.4 kilograms, has a length of 0.28 meters and has a short axis length of 0.17 meters\(^4\). Mathematically speaking, a football is classified as a “prolate spheroid”\(^3\).

The Dynamics Behind the Ball

A football rotates based on its long symmetry axis, where the axis’ direction of motion is determined by the way in which the center of its mass is moving. Its surface is swept out by revolving a circular arc around its long symmetry axis\(^4\). Because a football is not one-dimensional, the linear principle of force cannot be used to evaluate its movement. Force is given by the equation of $F=ma$, where “$F$” is equal to force (where the unit of measurement is given by newtons, or N), “$m$” is the equivalent of the object’s mass (expressed in kilograms) and “$a$” stands for acceleration (given in meters per second squared, or m/s\(^2\)). A football is angular, and falls under the definition of a torque. Its magnitude is measured by the equation of $\tau=rF\sin\theta$, where the magnitude of torque (given by “$\tau$”) is the product of the length of the position vector from a specific point (symbolized by “$r$”), the magnitude of the force “$F$,” which is the product of mass and acceleration, and the angle between the two is measured by “$\theta$”. Torque’s units of measurement is given by the Newton-meter (N \cdot m)\(^5\).

The average speed of an object is characterized by dividing the length of the path an object takes by the time that elapses throughout its travel. Acceleration is calculated by dividing the difference between an object’s final velocity and its initial velocity by the time interval in which the object travels, given by the equation of $\Delta v/\Delta t$ (where $\Delta v$ is the difference between final and initial velocities and $\Delta t$ is the time interval)\(^5\). But because a football is angular, the equations used to measure its movement become angular as well. A football’s average angular
speed is calculated by \( \omega_{av} = \frac{\Delta \theta}{\Delta t} \) (where “\( \omega_{av} \)” symbolizes the average angular speed, “\( \Delta \theta \)” stands for the change in angular measurement, and “\( \Delta t \)” is the change in time). Its average angular acceleration is given by the equation \( \alpha_{av} = \frac{\Delta \omega}{\Delta t} \) (where the average angular acceleration “\( \alpha_{av} \)” is the product of the change in angular speed “\( \Delta \omega \)” divided by change in time “\( \Delta t \)”)

Because a football is angular in shape, a quarterback must throw it with an overhand or sidearm motion to give it the spin it needs to follow the direction of its long axis. A football’s pointy tips are much smaller than the radius in its middle, significantly reducing its frontal area, allowing it to travel farther since it doesn’t have as many air molecules to work against the way it would if it were larger. The typical spin rate of a football is ten revolutions per second or 600 revolutions per minute.

**Gripping Forces**

The main physical force working behind a quarterback’s grip is friction, which is defined as resistance working against an object’s movement. The two differing types of friction both play part in how a quarterback handles the ball after it lands in his hands once snapped by the center. The force of static friction is the opposing force that works against an object’s initial movement, and is given by the equation of \( f_s \leq \mu_s n \) (where “\( f_s \)” is equal to the force of static friction that is less than or equal to the coefficient of static friction given by “\( \mu_s \)” and “\( n \)” is the product of the normal force of an object). Once the initial resistance an object encounters is overtaken, the second force of friction that the quarterback’s grip encounters is the force of kinetic friction. This is defined as the force that works against an object in motion. It’s calculated by \( f_k = \mu_k n \) (where “\( f_k \)” is equal to the product of the coefficient of kinetic friction given by “\( \mu_k \)” and “\( n \)” which is the equivalent of an object’s normal force).

A football is gripped by a quarterback by lacing his index, middle, ring and pinky fingers over the white laces on the top of the ball, his thumb at the bottom of the ball perpendicular to his fingers up top, and his palm turning into an arced form to grip the side of the football. A quarterback who throws with his right hand uses his left hand to settle the ball into his grip firmly, and left-handers follow suit using their right hand. The main gripping force lies within the quarterback’s fingers, as too much use of his palm becomes the source for “popping,” where the ball bounces off the quarterback’s hand and leads to short, inaccurate passes.

Because the main source of grip is dependent on the fingers, a quarterback with larger hands and longer fingers is more likely to be successful in passing the ball than quarterbacks who have small hands. Quarterbacks with big hands are more likely to have a firm hold on the laces and can adjust their grip more easily without looking, getting the ball out of their hands faster. Small-handed quarterbacks are left without this advantage, leaving their palm with more responsibility in holding onto the ball, which leads to wobbly passes.

**Letting It Go**

Releasing the football involves two ideas that include the center of mass of the ball and the center of pressure that’s exerted on it by the quarterback’s hold. The physical principle behind the release of the ball can be found within the concept of impulse. Impulse is defined as a constant force being delivered to an object over a certain time interval. The equation of impulse is \( I = F \Delta t \) (in which “\( I \)” represents impulse, which is the product of force given by “\( F \)” and the time interval in which the force was applied, given by “\( \Delta t \)”)

The release of a football is a function of both the force applied to it by the quarterback and how long he holds onto it before letting it go. The magnitude of the impulse in which a quarterback throws the ball can be measured when one looks at the area under the arc in which the ball travels in through the air; these are compared by force vs. time graphs.
As soon as the football’s released the aerodynamic drag starts and the center of pressure shifts forward of the center of mass. This happens because the drag force is directed towards the leading edge of the football and not the rear; this results in a right-hander’s throw veering slightly left and a left-hander’s pass moving towards the right initially. The direction switches right as the ball’s released, as the center of pressure moves forward of the center of mass and then the ball moves back to the side the quarterback was throwing with, leaving the overall lateral motion spinning in that direction.

A football traveling in the air has inertia, which is defined as the tendency of an object in motion to stay in motion. The path a football takes while in the air falls under the physical category of projectile motion, which is defined by the study of objects that move in both the x and y directions simultaneously under constant acceleration. If the effects of air resistance and rotation of the Earth are neglected, the path the football takes is in the shape of a parabola, and is defined as a parabolic trajectory. The parabolic trajectory that is measured is known in the football world as hang time, which is defined as the measurement of time that a football stays in the air after it’s been kicked.

Because the x and y values are separate from each other, their angles are measured differently. “θ₀” symbolizes the projection angle. The initial velocity in the x direction is assumed to be zero, and changes in the angle in which the ball’s released is calculated by \( v_{0x} = v_0 \cos \theta_0 \) where “\( v_{0x} \)” is the initial velocity when the time is equal to zero. The initial velocity in the y-direction is calculated by \( v_{0y} = v_0 \sin \theta_0 \). If air friction’s negligible, the acceleration in the x-direction equals zero, which means that the projectile’s velocity along the x-direction remains constant, and is mathematically expressed as \( v_x = v_{0x} t = v_0 \cos \theta_0 \). The horizontal displacement is given by \( \Delta x = v_{0x} t = (v_0 \cos \theta_0) t \). The vertical component of the football’s parabolic trajectory is affected by the force of gravity, which is given by \( a_y = -g = -9.8 \text{ m/s}^2 \). This results in three different equations. The first one is \( v_y = v_0 \sin \theta_0 - gt \), which calculates the velocity in the y-direction as the difference between the starting angle’s initial velocity (when time is zero) and the gravitational acceleration multiplied by the time the football’s in the air. The second equation is given by \( \Delta y = (v_0 \sin \theta_0) t - \frac{1}{2}gt^2 \), in which the change in the y-component is the result of multiplying the starting angle’s velocity at zero and the time elapsed, and then taking the gravitational acceleration and multiplying it by the time squared and dividing those numbers by two; these two products are subtracted from one another. The final equation is \( v_y^2 = (v_0 \sin \theta_0)^2 - 2g\Delta y \), where the y-velocity is squared on the left side of the equation, while on the right side the initial y-angle is squared, and the gravitational acceleration is multiplied by both the change in the y-direction and two; the multiplied gravitational component is subtracted from the squared initial angle, and all set equal to the y-velocity squared. At the maximum height of the parabolic trajectory, the football has a velocity of zero on the y-axis. An NFL quarterback can throw a football up to about 80 yards (73 meters) from a set position but because the likelihood of a quarterback being able to stand perfectly still while facing pressure from the opposing defense is small, the average throw is about 20 meters per second.
What keeps the ball continuing through flight is momentum, a vector quantity that is a function of the equation of $p = mv$, in which momentum (given by “$p$”) is a product of both an object’s mass (given by “$m$”) and its velocity (which is equal to “$v$”). As discussed earlier, the football has a unique angular shape, making all of its properties angular. This shape completely alters the way the ball travels through the air. Its momentum becomes angular, which is defined by movement due to rotation around an axis, and is found through multiplying the objects mass and angular velocity.

The aerodynamics of the football is based on how it spins along the long symmetry axis and travels farther and straighter when it works with the symmetry axis. There are three aerodynamic forces that act upon a football. The first force is a lift force that is caused by air collecting beneath the ball near its tip. The second force comes when a quarterback puts a spin on the ball. The air force that would normally cause the flying football to wobble is minimized because of the quarterback’s handling. The final force is due to Earth’s gravitational pull. Most football passes are thrown at an angle of thirty degrees and are caught at thirty degrees. When a football reaches the end of its parabolic trajectory, it tends to curve two or three more yards opposite of the direction in which it was thrown.

**Variables Impacting Quarterback Performance**

Weather affects how well a quarterback can grip a football; a study conducted by Antonio Valdevit of the Stevens Institute of Technology in New Jersey confirmed this when he took several volunteers and placed sensors on their hands while they gripped a football to calculate how much force they used in sixty-eight, forty-one and four degrees Fahrenheit temperatures. His results revealed that their generated force was all the same, but their middle fingers were weaker in the cold. A quarterback’s grip has only half as much strength in cold weather compared to what he normally has in warmer weather because his blood flow to his fingers is reduced to conserve warmth; most of the quarterback’s blood moves into their main organs and away from their extremities.

When studying the friction coefficient quarterbacks experience on their shoes as they move against the turf, their friction lessens as temperature decreases. The friction lost can be anywhere between ten to twelve percent, increasing the possibility of a quarterback losing his balance and slipping. Cold air also makes it hard for quarterbacks to breathe normally, since cold air is an irritant to lungs. This causes their chests to tighten, and turns an effortless everyday vital function into an uphill battle. In addition with being unable to breathe properly, many quarterbacks will find themselves with an insatiable itch to urinate constantly. As discussed earlier, as the body’s blood flow turns all towards the core organs in the body, kidneys become engorged with it. When the kidneys overfill, a miscommunication occurs within the urinary system that causes the organ to believe it’s overhydrated; thus the need to relieve it becomes an incessant annoyance. Quarterbacks who play in high-altitude environments often struggle in adjusting to these sorts of conditions. The higher the altitude, the thinner the air will be, which allows for easier breathing and overall functioning. These sorts of physical hindrances take away from not only a quarterback’s gameplay, but overall bodily equilibrium.

Cold weather’s nasty effects aren’t limited to the physical functioning of a quarterback. It also impacts the quarterback’s efficiency at the line of scrimmage and his passes. Colder air creates more density in the air, which causes a football to generate detectably higher levels of drag as it flies. A comparison drawn between the New York Giant’s Metlife Stadium in New Jersey and the Miami Dolphin’s stadium in Florida shows an increase of eight percent more drag in New Jersey’s cold weather. And if a quarterback tries to call an audible at the line of
scrimmage in cold stadiums, he’ll often find himself struggling with being able to communicate clearly to his teammates. Sound travels through the air faster in cold weather since dense air doesn’t conduct sound waves as readily. The difference is a four percent increase, making it harder for players to understand one another. The unfortunate results that could follow include botched snaps, lost fumbles, wrong routes being run and interceptions could’ve been avoided had it not been for verbal miscommunications.

To Wear or Not to Wear?

As the strategy and gameplay of football has evolved, the equipment worn by the players has done the same. When football was first played, players wore leather helmets that offered minimal head protection because the game had little physical contact. The first helmet was worn in the late 1800’s by either Joseph Reeves of the US Naval Academy or George Barclay of Lafayette College. It was referred to as a “head harness.” As time progressed and the game involved more tackling, the helmet’s composition had to be changed to protect the players. In 1915, earholes were put into the helmets to allow players to hear one another more clearly on the field. A suspension system was put in place to elevate the helmet from the top of the head so that a player’s skull wouldn’t feel the full force of a collision.

In 1939, John Riddell and his son John Jr. (founders of the football equipment manufacturer Riddell, still very much alive and thriving today) created the first plastic helmet, which was much more durable than its predecessor. The strap was moved from the neck to chin, and the suspension system was improved. In the mid-1960s, Riddell added vinyl and foam Aero-Cell cushions to the inside of the helmet, and because of plastic’s strength, facemasks could be added without ruining the helmet’s composition. The reinvention of the helmet was built around the head’s center of gravity and protecting the vital areas of the brain.

In 1939, all American colleges made it mandatory that their players wear helmets. The NFL followed suit in 1943 when rules were put into place requiring helmets being worn during games. In 1949, the plastic helmet became the NFL’s official headgear. Although the NFL still doesn’t have an official helmet-maker, Riddell by far remains the league’s first choice, as 83% of NFL players wear it. It also remains the brand of choice among collegiate footballers, as 62% of Division I players use Riddell’s model.

A popular topic of debate among coaches and quarterbacks questions whether or not the use of quarterbacking gloves has any impact on a quarterback’s performance. When one watches an NFL game being played in a stadium plagued by cold weather, it’s very common to see quarterbacks wearing gloves. As the temperature decreases and hands lose blood flow, a quarterback’s hand becomes rigid, making it harder to throw decent passes. In order to prevent this from happening, the gloves come on. Wearing gloves in cold weather neutralizes the harsh effects coldness has on the quarterback’s hands. The ball also becomes slicker during cold weather; quarterbacks wear gloves to improve their grip on these wet balls. Most coaches view gloves as an option that quarterbacks can use to aid them during wet weather, and nothing more.

Other football experts have challenged this narrow view of quarterbacking gloves, and wonder if gloves can be used on an everyday basis to give quarterbacks a tighter grip. A real life example of how gloves have impacted a professional quarterback’s performance for the better can be found in former NFL quarterback and league MVP Kurt Warner. Warner led the St. Louis Rams to two Super Bowl appearances and their sole Super Bowl victory in the 1999 NFL Season, where he was also named Super Bowl MVP. Warner later played for both the New York Giants and the Arizona Cardinals, where he led the Cardinals to their first and only Super
Bowl appearance in the 2008 season, which they lost to the Pittsburgh Steelers. Warner was brought into Arizona at the beginning of the 2005 NFL season, where he began as Matt Leinart’s backup. Towards the end of the 2006 NFL season, Warner started wearing quarterback gloves in order to give himself a tighter grip on the ball. During the 2007 regular season, Warner made four very impressive appearances as Leinart’s backup, completing 70% of his passes for 851 yards with four touchdowns and zero interceptions. It was noted that Warner was throwing a slightly tighter spiral than before as he put the gloves on throughout those games.13

Warner was insistent in stating that he believed putting on gloves had little to do with his improved performance; he credited a steadier offensive line for his success. Warner felt as if he had more control in the pocket because of the line, and that he was throwing the ball like he had throughout his entire career because he was finally given enough time to settle down in the pocket. However, Warner wasn’t entirely dismissive of the improved grip his gloves had given him.13 And throughout the remainder of his career up until his retirement after the 2009 NFL season, Warner would continue to wear quarterbacking gloves on a consistent basis.

Another prime example of quarterbacking gloves can be found in Denver Broncos quarterback Peyton Manning. Throughout most of Manning’s career with the Indianapolis Colts from 1998 until 2012, gloves were hardly ever seen on his hands. After undergoing highly publicized surgical procedures on his neck and sitting out during the 2011 NFL season, Manning returned for the 2012 season as the new starting quarterback for the Denver Broncos. During the last two games of the 2012 regular season, Manning started wearing gloves. Manning’s hands were initially weakened after his intense surgeries, and he himself admitted that had he not been injured the previous season, he most likely wouldn’t have needed gloves. But as part of getting used to his new body, Manning needed to make some adjustments to his gameplay, including improving his grip. He found this through quarterbacking gloves.12

Most quarterbacks choose to forgo gloves because they dislike the loss of “feeling” the ball that gloves cause. It’s traditional for quarterbacks not to wear gloves unless they’re playing in cold weather, so most quarterbacks choose to follow this unspoken rule. Many feel that gloves are uncomfortable because they grow up playing football without the gloves.14 Basically, gloves are looked at as “unorthodox” for quarterbacks to use. Given some of the evidence shown through Warner and Manning’s example, the effects gloves have certainly can’t hurt a quarterback. In fact, gloves may help a recovering, older quarterback struggling to get his game back, which is what happened with Manning and Warner. There hasn’t been quite enough research done on how much gloves impact quarterback performance, but one might want to reconsider this “tradition” of teaching quarterbacks to throw bare-handed, and incorporate a possible performance enhancer found through gloves.

The Makings of a Quarterback

To become a great quarterback, a great deal of both physical and mental preparation is required. According to Donnie Yantis, former head coach of Paradise Valley High School’s football team and current head coach of Arizona Christian University’s up and coming football
team, it’s a “year round” job for college quarterbacks. Mike Norvell, the quarterback’s coach for Arizona State University, emphasizes that both aspects are of vital importance in the world of quarterbacking, both at the collegiate and professional level.

Yantis goes on to describe a quarterback’s typical physical regime as one that consists of weight training, strength and flexibility exercises, specific arm training exercises that involve both lifting weights and throwing the football, and footwork exercises. The footwork exercises Yantis has his quarterbacks run through include ladders, line-work, jumping bags and taking snaps and drop-backs with their offensive line. These workouts take place at least four times a week, and begin at 5:00AM for his quarterbacks.

Norvell emphasized that along with typical drilling, a basic understanding of balance and timing is crucial to a quarterback’s gameplay. According to him, it’s important that a quarterback has a strong core and toned muscles. Although he insists that there are exceptions, for the most part, he prefers taller quarterbacks (at least six feet two inches) who can see over the offensive line easily; he also looks to see that his recruits be over 200 pounds. The quarterbacks at Arizona State get half an hour to work on their own drills individually, and spend another two and a half hours practicing with the rest of the team.

The offensive weapons a quarterback needs to perform at a high level include a steady offensive line who will offer him plenty of protection and time to get his passes off, intelligent receivers at the perimeter who know how to win one-on-one matchups and a strong running game in which the backs know how to put defensive players in the box. A recent trend in the NFL that has taken off is the popularization of a “running,” dual-threat quarterback who can not only play as a pocket-passer, but can take off on opposing defenses and run all over them. These quarterbacks include Seattle Seahawk’s Russell Wilson, San Francisco 49er’s Colin Kaepernick and Washington Redskin starter Robert Griffin III.

“I think it’s just a fad that the NFL is going through right now,” Donnie Yantis says. He believes that although the idea behind them is exciting to both coaches and fans, it simply doesn’t work in the long-run. As evidenced with Michael Vick, NFL defenses eventually figure out their running schemes, build around them and force the quarterback to stay in the pocket and pass like they normally would. The other issue that arises when a quarterback is a chronic runner is that their likelihood of getting injured becomes even greater; as seen with Robert Griffin III, reckless running led him into a devastating torn ACL, and his play has deteriorated since.

In addition to possessing superb athleticism, a great quarterback must be equally (if not more) superior intellectually. Mike Norvell believes that mental ability is the most undervalued quality when quarterbacks are measured. He also believes it’s the most important.

“Mental preparation is probably the biggest part of quarterbacking,” Norvell elaborates. “That’s what separates good quarterbacks from great quarterbacks. The mental preparation a quarterback goes through involves watching hours of film, understanding both offensive and defensive schemes, and concepts. They have to know all of this. They direct the whole offense.”

Donnie Yantis was vehement about the importance of watching film and studying the game as well. He states that his quarterbacks spend between four to five hours a week watching film.

The key tool of measurement that both of these men use to decide whether or not a quarterback has the mental capacity needed is through looking at their GPA. According to both of them, there’s a direct correlation between good grades and being able to execute plays on the
field with precision. The intelligence that is used in taking tests can be applied on the field when reading defenses and in the film room when studying tape.

Donnie Yantis got his start in the world of coaching football after being inspired by his former coaches from his high school and college playing days. According to him, they made his life better, and he hopes to give back the same way he was given to. He started playing football at the age of fourteen and played all throughout high school at Paradise Valley High School. He played mostly at the positions of running back and defensive back; he played quarterback for a short while. He struggled during his first year of college, and turned to his former coaches once again for help. He decided to go back to school after that, and graduated after 4 years with his bachelor’s from Southern Utah University. After he earned his master’s degree from Northern Arizona University, he earned his first head coaching position at Glendale High School. He got into the field because he loved the ideas behind coaching. Yantis has coached at Paradise Valley High School, Glendale Community College, Glendale High School and currently holds the position of head football coach at Arizona Christian University.

Mike Norvell traces his playing days all the way back to when he was just five years old. He played quarterback while he was in high school, and played wide receiver in college at the University of Central Arkansas. He credits his inspiration back to influential coaches that he had growing up. Norvell enjoys the schematics behind football, and hopes to give back and direct futures like he experienced. He was a graduate assistant at his alma mater for six years, and then received his first official full-time job at the University of Tulsa. He spent four years there until he accepted another position at the University of Pittsburgh. In 2012, Norvell was hired as the offensive coordinator/quarterbacks coach at Arizona State University. He has been coaching for nine years.

When asked which quarterback they feel is the best in the NFL as of this moment, they both shared one particular quarterback in common: Peyton Manning of the Denver Broncos.

**Peyton Manning**

Peyton Williams Manning was born on March 24, 1976 in New Orleans, Louisiana to hometown legend Archie Manning and former Ole Miss homecoming queen Olivia Manning. His father, Archie Manning, played for the University of Mississippi Rebels from the late 1960’s to the early 1970’s, where he earned the honorary title of being the greatest quarterback ever to set foot on their turf. Unfortunately, Archie’s NFL career didn’t turn out to be nearly as spectacular as his collegiate career had been, as he was drafted to play for the hapless New Orleans Saints (jokingly referred to as the “Ain’ts”) throughout the 1970’s. The ineptitude Archie played with is evidenced through the unfortunate record he holds as the quarterback with the worst winning percentage in the entire league’s history at a lowly 0.263 (minimum 100 games)\(^{15}\).

Peyton Manning followed in his father’s athletic footsteps as he entered Isidore Newman High School in New Orleans to start as their varsity quarterback for three seasons. It was here that he posted a 34-5 record in his three seasons as a starter, and was named Gatorade Circle of Champions National Player of the Year and Columbus (Ohio) Touchdown Club National Offensive Player of the Year as a senior. He attended college at the University of Tennessee, where he held the job as starting quarterback all throughout his freshman to senior year. During his freshman season in 1994, Manning was named SEC Freshman of the Year after starting 8-of-11 games. The next year, Tennessee went 11-1 with Manning under center as a sophomore, with the season ending in a Citrus Bowl win against Ohio State University. He was named a consensus All-American and was the Heisman Trophy runner-up as a senior in 1997 after
leading the Volunteers to an SEC Championship. In the SEC Championship of that year, Manning was named MVP after completing 25-of-43 passes (58.1%) for 373 yards with four touchdowns and two interceptions in a 30-29 win over Auburn University. In 1998, the Indianapolis Colts drafted Peyton Manning as the first overall draft pick. Manning would become their starter that same year, where he played in all 16 games and set both Colts and NFL rookie records for completions (326), attempts (575), yards (3,739) and touchdowns (26). He was selected to his first of thirteen career Pro Bowl elections during his sophomore season in 1999, and his Pro Bowl selections remain a record among NFL quarterbacks today. He received his first NFL Most Valuable Player honor in addition to being named first-team All-Pro by the Associated Press after starting all 16 regular-season games and completing 379-of-566 passes (67.0%) for 4,267 yards with 29 touchdowns and 10 interceptions during the 2003 season. During the 2005 season, Manning was selected as the honorary recipient of the Walter Payton Award.

In the 2006 season, Peyton Manning led the Indianapolis Colts to the AFC Championship, where he orchestrated a spectacular halftime comeback against his archrival Tom Brady and the New England Patriots from a 21-3 deficit. Manning helped tie the game in the third quarter, and led the Colts to victory with a thrilling 80-yard drive in the last two minutes of the game to put them ahead by 38-34 with 1:02 left in the game, enough to lead the Colts to Super Bowl XLI. The Colts went on to win Super Bowl XLI and defeated the Chicago Bears 29-17, where Manning was given Super Bowl XLI MVP honors as he posted 25-of-38 passes (65.8%) for 247 yards with one touchdown and one interception. He led the Colts to another AFC Championship victory in 2009 to top off a postseason in which he had culminated 87-of-128 passes (68.0%) for 956 yards with six touchdowns and two interceptions, where they ultimately fell short to the New Orleans Saints.

In 2011, Peyton Manning sat out the entire NFL season due to intensive neck problems and complicated surgical procedures to correct them. His streak of 208 consecutive starts ended. The next season, after being released as a free agent by the Colts, Manning signed with the Denver Broncos, where he started all 16 games and set Broncos franchise records in completions (400), completion percentage (68.6), passing yards (4,659), touchdown passes (37) and quarterback rating (105.8) and an AFC Divisional playoff appearance, where he fell short in double overtime to eventual Super Bowl XLVII Champions Baltimore Ravens. He also received the NFL Comeback Player of the Year Award and was runner-up in MVP voting that year.

The NFL 2013 season turned into a time of rewriting the record books, as Peyton Manning set the league on fire as he set NFL single-season records in passing yards (5,477) and touchdown passes in 2013; he set Broncos single-season records in nearly every major passing category in 2013, including completions (450), attempts (659), passing yards (5,477), touchdown passes (55) and quarterback rating (115.1). He gathered his fifth MVP award and led the Denver Broncos to Super Bowl XLVIII, his third appearance, where they lost 43-8.
Manning’s Precedents

Peyton Manning has set an unmatched precedent among quarterbacks both at the professional and collegiate level. Manning ended his collegiate career with the most wins in SEC history (39-6), including a 26-4 mark as a starter in conference games, and ranks third in NCAA history with 11,201 passing yards. During his time at Tennessee, he posted 33 school records, eight Southeastern Conference marks and two NCAA standards. Manning ranks second all-time in passing touchdowns (491), yards (64,964) and completions (5,532) and is third in attempts (8,452) in the NFL. He owns the most 4,000-yard passing seasons (13) in NFL history and is the only player to throw for more than 3,000 yards in his first 13 professional seasons. Manning also holds a record of five NFL MVP trophies, the most MVP awards held by any player of any position in the entire league’s history. He’s been touted as one of the NFL’s greatest role models with his strong work ethic, study habits, citizenship and leadership abilities. In 1999, Manning created the Peyback Foundation to help disadvantaged kids, and has raised over $6.5 million for youth-based community programs in Colorado, Indiana, Louisiana and Tennessee. Even after leaving the Colts, Manning has continued to keep a strong ties with St. Vincent’s Children’s Hospital in Indianapolis, which in 2007 was renamed the “Peyton Manning Children’s Hospital at St. Vincent.” Manning is also a member of the American Red Cross National Celebrity Cabinet and the Board of Visitors of the College of Arts and Sciences at the University of Tennessee. He also continues to give back to his alma mater by creating the Peyton Manning Scholarship program at Tennessee, which has honored 20 incoming college students in the last 16 years based on outstanding academic performance, leadership and community service. Peyton Manning is also the older brother of New York Giants quarterback Eli Manning, the 2004 first overall draft pick and two-time Super Bowl Champion and MVP of Super Bowls XLII and XLVI. He also has an older brother, Cooper Manning, a wide receiver whom he played with during his high school years.

Manning’s Mechanics

Peyton Manning has become famous for his “chicken dance” hand motions at the line of scrimmage and his no-huddle, hurry-up offense. Manning also possesses very large hands, which are crucial to his success in not fumbling the football. As discussed earlier, after his neck surgeries in 2011 weakened the nerves in his body that control his grip, Manning needed some help in regaining his superb ball-handling skills. For this reason, Manning became a regular glove-wearer after having custom-designed gloves created specifically for his hand dimensions. The Pro Football Focus has Manning as the league leader in release time, as he takes a mere 2.36 seconds to throw the football. He receives the snap, identifies where the laces are on the ball and then releases the ball as fast as he possibly can.

Peyton Manning has also been labeled as having “happy feet” while trying to settle in the pocket before releasing his passes. This habit of Manning’s serves as an example of the physical
principle of work. Work is a product of both the magnitude of the force acting on an object and the magnitude of an object’s displacement. The linear displacement of work can be found through the equation of \( W = (F \cos \theta) d \), where work (given by “W”) equals the multiplication of the force (given by “F”) at the angle of which the force occurred at in respect to the x-axis (given by \( \cos \theta \)) and the displacement in which the angular force was applied (given by “d”). Work’s units are expressed in joules.

Manning’s footwork is not limited to movement just along the ground, however, as his feet move in an up and down motion. For this reason, the principles of kinetic energy and potential energy must be incorporated when analyzing Manning’s movement. Kinetic energy is the product of an object’s mass and speed, given by the equation of \( KE = \frac{1}{2}mv^2 \) (where “KE” is kinetic energy, “m” is equal to the object’s mass and “v” is the object’s velocity, all divided in half). The units of measurement are given in joules. Potential energy is not dealing with just an object; it is concerned with the position of that object and how it interacts with Earth’s gravity. It is calculated by the equation of \( PE = mgY \), where potential energy “PE” is the product of the mass of an object (given by “m”), the gravitational acceleration (symbolized by “g”) and the vertical position of the object (given by “y”); the results are expressed in joules. These two equations relate to one another through the idea of the conservation of mechanical energy, which states that although the form of energy may change, the physical quantity of that energy remains the same throughout the physical process. For this reason, kinetic energy and potential energy can be related to one another by the equation of \( KE_i + PE_i = KE_f + PE_f \). The left side of the equation displays the initial values of an object’s kinetic energy and potential energy, while the right side represents the final values of an object’s kinetic and potential energy.

When Manning’s feet touch the ground, his potential energy is equal to zero because his distance from the ground is zero. When he does touch the ground, his potential energy’s translated to kinetic energy as he moves along the ground with a certain velocity. And his kinetic energy can become potential energy once again the moment his feet leave the ground, because his position to the Earth in the y-direction has grown.

Peyton Manning’s playing style has been compared to that of Hall of Fame quarterback Dan Fouts from the San Diego Chargers of the 1970’s and 1980’s. Many football experts have drawn eerily similar comparisons between Manning and Hall of Famer Dan Marino, the legendary quarterback of the Miami Dolphins from the 1980’s to the 1990’s. He is also infamous for his shouting of “Omaha” at the line of scrimmage. Many experts have tried to figure out exactly what Manning means when he calls this audible, but their findings were inconclusive. Most of the time when Manning calls this, it’s a signal that the ball is going to be snapped within the next few seconds. In order to confuse the defense, Manning will use a secret code before shouting Omaha in order to bring the opposing defensive line forward, thus eliciting an offsides penalty in Denver’s favor. According to former Chicago Bear linebacker Brian Urlacher and former New England Patriot wide receiver Randy Moss, Omaha is also typically a code word used to tell the offense to run whatever play they had decided on using to the side of the field opposite of what they originally planned to beat the defense (a “flip-play”). Ultimately, it’s an audible that stands for whatever Manning wants it to mean for that specific play; it’s a source of confusion and frustration among the opposing defenses.

The Future of Quarterbacking

Upon reviewing the research that this paper uncovered in correlating the laws of physics to football quarterbacking, and considering the ever-changing landscape in the world of technology, I believe that if more physicists and football strategists alike would work together to
build the equipment, gameplay and the training of quarterbacks around the eternal laws of physics, we would see less injuries, more efficient quarterback play and more practical schematics applied in the game of football. When one really stops to look at how physics work, it makes sense as to why the game of football is the way it is. When we understand the laws of aerodynamics, it becomes clear as to why a wide receiver wasn’t able to convert on a crucial third down as the ball veered away towards the left at the end of its parabolic trajectory due to the gravitational pull, and they were unable to reach out for it before it hit the ground and was ruled as an incomplete pass. When we understand how that works, receiver’s coaches can use it to be incorporated into how they train their receivers to run routes, and prepare them to veer along with the ball down its turn on its path of flight. All of a sudden, seemingly impossible catches become doable thanks to a basic understanding in how the law of gravity works.

This paper focused mainly on the role of the quarterback and what makes NFL quarterback Peyton Manning such an exemplary role model for quarterbacks of all ages to follow; once again, we can correlate his quarterbacking success to his working in sync with the realm of physics. With his large hands and new gloves that enhance his already firm grip on the football, Manning serves as a textbook example of working with the physical principles of friction. It is through physics why we also understand how his quick release time, which is a function of impulse, causes the ball to travel at the rate it does. When we consider the physical principles that factor into impulse, quarterbacks can be taught through film studies with what rate of time their passes need to take off and how much force they must generate for it to garner the positive results they’re looking for. These learning moments can then be carried to the field, executed the way they’re supposed to be and bring forth the successful plays needed to win the game.

Conclusively, after looking at the intensive research that’s been presented here in this study, I believe that “physics” and “football quarterbacking” should be synonymous among football coaches, players and fans alike. Through understanding the concepts of physical theories, watching the sport of football, specifically analyzing the role of the quarterback and taking all three parts to look at why a great quarterback like Peyton Manning is so successful, we can develop a greater appreciation for the world of science and help shape quarterbacks into the amazing athletes we hope to witness. Building the game of football around the world of physics, and finding ways for the two of them to work with one another, will result in spectacular plays, improved gameplay among players of all positions on both sides of the ball and breathtaking moments and victories that only the great sport of football can bring.


Quite a Blast

Bojan Tuco

Professor Jenny Weitz

March 28, 2014

AST 112
A nuclear explosion. Feared by all on this earth due to the tremendous force it unleashes upon its unfortunate victim. A blinding ripple of energy that can turn a once inhabited beautiful town into nothing but a radioactive wasteland. Nothing bigger can come to mind in terms of destruction. Now take the most powerful bomb ever created (2000 times more powerful than the bombs used in WWII) and think about how much destruction it could truly bring about. Mind blown? That would be a heck of a light show to say the least. Now take that astronomical explosion and produce about 6 quintillion of those warheads and you will have what astronomers like to call a Supernova. Emphasis on Super. A Supernova is a truly cataclysmic event that occurs in outer space in a couple of ways, when a large star unlike our sun known as a Red Giant uses up all of the elements it can to undergo fusion collapses on itself and rebounds in a way that a human mind cannot even fathom.

An explosion so massive, so bright, and so monstrous it can be seen easily from earth with the right equipment. Sometimes even with the naked eye such as Kepler’s Star which occurred in 1604. The explosion of star SN 1604 was 20,000 light years away and was still visible by the naked eye, even during the day for three whole weeks. (Ron Cowen) The fact that something so far can be seen with the naked eye due to the scale of the explosion truly puts things in perspective. What the heck is an atomic bomb a Supernova? A speck of sand to the largest beach one can find.

A star going supernova is truly a fascinating process. A star with a large enough mass, when it starts to run out of helium to use for fusion looks to battle the inevitable by consuming heavier elements to lengthen its life. A lesson to be learned, no matter how big, nobody ever wins the battle against gravity. Eventually a star will get to a very heavy element like iron. By now the star is much more out of control and it has expanded by a large amount. The star is
much more unstable as performing fusion with heavy elements causes this. Eventually gravity has its way.

Gravity wins this arm wrestle and forces the star to collapse within itself. Now the force of that fusion and elements collapsing with gravity is immense and like a small bouncy ball ricocheting off of a basketball the force that is rebounded back out from the collapse is terrifyingly catastrophic. A bright explosion commences, and a Supernova is born.

Other than the big bang, nothing can compare to the scale of this ravishing explosion as anything even remotely close in the space is consumed. To put it in perspective, if our wonderful sun went supernova, Planet Earth would be vaporized with nothing remaining in a very short amount of time. Luckily we don’t have to worry about this as our sun is a smaller star that does not hold enough mass to ever undergo this fiery goodbye. So on the bright side we still have a solid 5 billion years to figure out space travel to the fullest. Now back to supernovas, and the mass that dictates whether a supernova will take place at the end of a star's life.

Now a smaller star with the mass close to or equal to the sun, will not be massive enough to undergo this stage as aforementioned. This is because these smaller stars are unable to do fusion with heavier elements such as iron like a Red Giant for example would. This results in the star slowly expanding over time into a Giant until it basically dies off and becomes a tiny white dwarf that slowly dies off with a planetary nebula surrounding it. A larger star, ie a Red Giant is so massive that fusion with these heavy elements results in that rebound that causes the supernova. Once the Supernova commences remnants will last for a couple years until it calms down. Remaining will be a neutron star. This miniscule planet ranging usually around 10 km is tiny but can be more massive than the sun. To fully comprehend this, a simple matchbox that
barely weighs anything on earth would weigh a staggering five billion tons on a neutron star. Quite a load. These itty planets are the most dense stars our neverending universe contains.

Are they the most massive object in the universe though? Not at all. In order for a planet to go supernova it must be extremely massive. Now take that upper echelon of massive stars and pick out the most massive of the massive. What happens to them? The wonder of space that nobody truly knows the truth about. A black hole.

If a star is immense enough, it can indeed leave behind this astronomical wonder behind after the spectacular supernova. A black hole truly lives up to its name as it leaves nothing behind besides darkness. Not even a spec of light can escape this black body. (Ron Cowen) The theory of general relativity even predicts that this ominous region of space can break down space and time once it hits the event horizon otherwise known as “the point of no return.” In more movie like events it could be possible to manipulate time if using a black hole due to time and space becoming rather infinite due to lack of better word choice. Based on how spectacular and intriguing a supernova is, it is entertaining to think that a black hole rivals it in terms of how epic it is!

These black holes are results of the massive stars going supernova and are some of spaces most mind blowing features. It is difficult to put in perspective how large of an explosion it would take for this event to occur. It would be quite a sight to see, but at the same time nobody would want to be even remotely close to such a calamitous event in space. (Lucas Laursen) Luckily we don’t have to worry about in currently in our position on earth.

The question is what if we had to worry about a supernova? What if there was a potential red giant close enough to earth to affect us. What would occur? A multitude of events would be the answer. Not very good events. The closest threat we have is our friendly super giant
Betelgeuse. This star is our closest threat as it is “only” 640 light years away. A rather insignificant distance, right? Betelgeuse is nearly at the end of its fusion process and is running out of elements to consume and is expected to go supernova somewhere in the next millennium. Fortunately, at 640 light years away, the chances of this explosion harming Earth is insignificant as it is predicted that a star would have to be within 26 light years or less away from Earth in order to hurt our Ozone layer. (Lucas Laursen)

Weren’t we to be within that range of 26, the results for the human race and mother earth would be nothing short of catastrophic. The biggest problem would be the gamma rays emitted from the explosion that would cause a chemical reaction to the earth’s ozone layer. The protective layer would be depleted allowing harmful solar and cosmic rays to wreak havoc upon all life on earth. The radiation would devastate the circle of life as we know, particularly marine life. Such a calamity would mark the extinction of the human race. (James Foley)

Scientists have already found traces of past supernovae via rock strata located in deep sea Pacific Ocean. These rocks contained traces of metal isotopes in the form of iron-60 which hints towards a supernova. It is estimated that it occurred in the last 5 million years due to the signs of the iron-60 still being there. (Jacco Vink) The supernova must have been very close to our solar system, relatively speaking of course.

The frightening part of this is the fact that this explosion was devastating enough to cause mass extinction. That means that our timing was great, because had it happened during the time of man, the human race would have been vaporized.

It is staggering to try to actualize the gravity (no pun intended) of the devastation caused by this galactic event. To try to put it in perspective, take driving from Arizona to California. It appears as if a large amount of land is covered. Now imagine the range of destruction caused by
a supernova and it is clear that it is a beach compared to a mere speck of sand. Even that does not
do a supernova justice. A drop of water, in the Atlantic Ocean perhaps? The point being, Outside
of the Big Bang, a supernova is the most powerful release of energy that can be seen. The irony
is that this fascinating eruption of force helped shape our solar system to be the way it is.

The nature of space is wildly unpredictable, but at the same time everything makes sense.
We see so much into space but yet know so little in actuality. Due to the vast amounts of
unknown elements of space and the fact that it has not been a mere century since we first
voyaged into the unknown realm of space, it is only the beginning of our knowledge. We have
only scratched the surface in uncovering all the mysteries space withholds from us. From the
Big Bang, to dark matter, to the infinitely large void of space we don’t know a thing about, space
is filled with answers. Of course, those answers unlock a whole new set of questions. One thing
we know for sure is that: A supernova is the most powerful lightshow space puts on display, how
and why these wondrous events occur, and what would happen to us if caught in the middle of
one. In closing, let us sit and admire the wonders of this galactic event and learn as much
as we can from it, while crossing our fingers that we can steer clear of the wrath of a supernova.
Annotated Bibliography


This article discusses objects that are of interest because they uncover more information about supernovas. They show x-ray observations that show supernova explosion mechanisms. They are results of galactic cosmic rays. Many of these remnants contain special plasma that also offers a lot of information.

Cowen, Ron “The Cataclysmic Death of Stars” *National Geographic* (2013) pg. na

This article is more of an intro to supernovas and shows a look into what a supernova is. The elements that make up a supernova are also included. Really a solid first take on supernovas that gives a general idea of what is actually going on in these cataclysmic events.

Kruesi, Liz “What Caused Supernova 1006?” *Astronomy* (Jan, 2013) pg. 12

This article takes an inside look at the type Ia supernova, which was once a white dwarf. It collected a lot of mass until it finally exploded and destroyed itself. Scientists still are trying to figure out how this star acquired the energy it did.

Harrington, J.D. “Supernova Blast Provides Clues to Determining Age of Binary Star System” *Nasa* (Dec, 2013) pg. na Web.

This article refers to data found by the Chandra X-ray observatory showing how faint supernova remnants helped researchers find many astronomical objects and classify certain astronomical objects.
An expanding nebulosity known as Kepler’s supernova remnant is over 40 years old. This supernova remnant has many secrets that are continuously being unfolded with time.


This article discusses the eruption of a star in the nearby galaxy M82. It is the brightest supernova since 1987 when a monster exploded 168,000 years away.


This article discusses the supernova that is imminent in our Milky Way galaxy as stated by a team of scientists from Ohio State University. They state that there is a 20% chance that it will be visible with the naked eye.


In the Whirlpool Galaxy a supernova which uncovered many mysteries about what really happened to a missing supergiant star.
The Orion Nebula

Laurentin Walker

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Professor Jenny Weitz
Abstract

The Orion Nebula is one of the most frequently observed nearby star forming regions; and is also the subject of a large bibliography of observations as well as interpretations. Herein are discussed panchromatic observations of the massive OB stars, variable stars within the Orion Nebula, and the blister HII region. Such information includes but is not limited to the nebula’s location, 400 years of observation history, as well as the color and structure of the nebula. Discussion also includes the nebula’s distance from Earth; as well as the historical and current constraints on the distance to M42’s cluster. Star formation within the nebula as well as the evolution, and other physical characteristics are also included within this report. Overall observation of M42 as a whole is also presented.

Based on our knowledge of the Orion Nebula, an interesting hypothesis was drawn; 50,000 years ago the Orion Nebula was invisible to the naked eye. The ionizing photons of the massive O and B type stars whose arrangement gives the namesake “Trapezium,” had not yet burned away the layers of natal molecular gas out of which they formed. While there were bright blue stars visible along the Sword of Orion, having formed continually millions of years prior, there were possibly more stars than there are presently, with thousands of smaller stars hidden from view. In the interim, a blister HII region formed by a newborn 40,000K O type star expanded into the molecular cloud, thus uncovering a large portion of the embedded star clustering; however star formation is still happening today within the remaining molecular cloud. The Orion Nebula is known by more than one name; some other names include Messier 42, M42, and the “Great Nebula.” M42 is located in the Orion constellation in the middle of the stars that make up Orion’s sword. Messier 42 is considered to be among the brightest of all the nebulae observed; it is so bright, that it can be seen with the naked eye. It will appear quite fuzzy to observers with
sharp eyesight. During the 50 Year period after the telescope was developed in 1608, the stellar content and the nebular nature of M42 was independently discovered by several observers. The observation logs of Nicolas-Claude Fabri de Peiresc (1610) and of Johann Baptist Cysat (1618) and also Wolf (1854) and Holden (1852) represent the earliest written records that the Sword of Orion contained a “fog” or “milky nebulosity.” These were in fact the words that W. Herschel (1802) used to describe the region. Galileo (1617) produced the first hand drawn chart of M42; however he did not distinguish the nebula. Giovanni Battista Hodierna (1654) also produced a hand drawn chart. Unlike Galileo, he did distinguish the Orion Nebula. M42 was first sketched in 1659 by Dutch astronomer Christiaan Huygens during the first days of the telescope. There is a portion of the Orion Nebula named after him in recognition of this due to his accurate rendition of the central nebula surrounding the massive OB stars. A journal comprised of 273 years of telescope aided visual observation was provided in Edward S. Holden’s “The Monograph of the Central parts of the Nebula of Orion” (1882) Holden reproduced dozens of hand drawn sketches of M 42 and included these in his monograph as well as the sketches from Henry Draper. (1880) 100 years after the Holden monograph, C. Goudis produced The Orion Complex: A Case study of Interstellar Matter. This useful publication focused on the structure and the nature of the nebula itself. Its details included past approaches to studying the nebula and its content including infrared, radio, and spectroscopy. Additionally the number 42 is derived from the French comet hunter Charles Messier who in 1771 numbered the Orion Nebula “42” on his list of fuzzy objects that were not comets. M42 is also one of the first objects observed by researchers using the Hubble Space Telescope.

There is a 10-15% level of uncertainty as to the exact distance of the Orion Nebula. The distance to the nebula was analyzed then re-analyzed by Minkowski. (1946) His statement
concerning the distance of Messier 42 is still in effect today and is as follows: “All published values of the distance of the Orion Nebula are open to some criticism. The geometry and the kinematics of the Orion Nebula region as a whole are complex, which is why the estimation of exact distance is so difficult to obtain. The Orion Nebula is located at a distance of roughly 1400 light years. In terms of parsecs, the Orion Nebula is roughly 400 parsecs away from Earth. M42 has a diameter of 20 to 40 light years. M42 is surrounded by a giant cold star forming region of gas and dust. This molecular cloud is extremely dense; which makes it more likely that stars will form. Due to the density of the cloud, star clusters are often hard or impossible to observe; however if a star should form near the surface of the cloud, the radiation as well as the stellar winds would push all of the dark cloud material hiding the star clusters away. This process was indeed the case with M42, as such scientist are able to see nearly all of the stars that have formed there. The Orion Nebula cluster was the first cluster of pre-main sequence stars to be detected in the x-ray band (Giacconi et al. 1972) and non-imaging studies soon found that the x-ray emission is extended on scales of a parsec of larger (Bradt & Kelly 1979). Some early explanations for X-rays of the the Orion Nebula included winds from the massive OB stars colliding with each other or with the molecular cloud as well as hot corona or magnetic activity in lower mass stars. The Einstein (Ku & Channa 1979), ROS AT (Gagne et al. 1995) and ASCA (Yamauchi et al. 1996), imaging X-ray observatories established that both the massive OB stars and the lower mass T Tauri stars contribute to the X-ray emission. The Orion Nebula Cluster was intensively studied during the first year of the Chandra mission; several instrumental setups were used, and are as follows: the Advanced CCD Imaging Spectrometer (ACIS) in imaging mode (Garmire et al. 2000; Feigelson et al. 2002a, b, 2003) and as a detector for the High Energy Transmission Grating Spectrometer (Schultz et al. 2000, 2001, 2003a,b), and lastly with the High Resolution
Imager (HRI; Flaccomio et al. 2003a,b). The results that emerged from this study were many as well as valuable; however it was soon realized that more would be learned only after a deeper and longer exposure of the Orion Nebula region. This was finally accomplished during the fourth year of the Chandra mission. At that time Chandra performed a 10 day nearly continuous observation of M42; this was unprecedented. This particular mission was nicknamed the Chandra Orion Ultradeep Project (COUP). The COUP study detected in excess of 1600 X-ray sources, of which 1400 are young stellar objects (Getman et al. 2005c). M42 is the closest region today nearly Earth where which massive stars are forming. Astronomers, through the use of spectroscopy and photometry have measured the cluster stars of M42 so that their intrinsic brightness and surface temperatures could be determined. This data was then compared to computer models of newly formed stars which enabled scientist to derive the age of the star cluster (Hipparcos Astrometric Spacecraft). Star formation in the Orion Nebula has been going on for the past 2.5 to 3.5 million years. Within the surrounding molecular cloud are about 700 to 1000 stars; most of these stars have not yet reached their main sequence stage which would indicate that the stars in the Orion Nebula Cluster are still in their infancy. There are a group particular stars within M42 that burn so bright that they illuminate the whole of the Orion Nebula. These stars are young, hot, bright, and can be seen through amateur’s telescopes. These four stars are known as the “Trapezium.” (Trumpler 1931) Messier 42 is the portions of illuminated gas and dust leftover from the formation of these stars. A large amount of ultraviolet radiation is emitted once a massive star forms within the cluster. Any surrounding atoms then absorb the energetic photons from the star while at the same time removing one or more of their orbiting electrons. This results in electrically charged atoms; this process is called ionization. In short, ionization results in the formation of emission lines whose light penetrates Earth’s
atmosphere to enable scientists to observe. Scientist use several techniques to identify variable stars. For example photometric variability; this traditional technique is used to identify young members of a star forming region. Other methods used include kinematics (proper motion and radial velocities), presence of lithium in the photosphere, and stellar/circumstellar activity exhibited as X-ray emission, UV and optical emission lines and/ or infrared excess. The Orion Nebula Cluster is a collection rich in variable stars. According to Herbig (1982), the first variable star that was identified within the Orion Nebula was observed by W.C. Bond in or around 1848. This star is now known as AF Ori (Herbig 1982). Herbig also noted in 1982 that in addition to the known eclipsing binary members of the Trapezium itself (Ori A and Ori B), there were 17 named variable stars in the Trapezium region (inner Orion Nebula Cluster), and several hundred within the larger nebula. Today this area is known to contain several thousand young stars of which the vast majority are known variables based on modern optical CCD and infrared array monitoring surveys. The massive stars in the Orion Nebula Cluster have been the objects of study concerning their multiplicity. Light curves have revealed a number of eclipsing systems (e.g. Parenago & Kukarin 1947; Hall & Garrison 1969; Lohsen 1975; Wolf 1994), which have been analyzed further to identify additional companions (e.g. Vasileiskii & Vitrichenko 2000). The search for spectroscopic companions was presented by Abt et al (1991). There were studies that detected visual companions to the massive OB stars; these studies include Padgett et al. (1997), Petr et al. (1998), and Simon et al. (1999). Preibisch et al (1999) performed a systematic survey for multiple systems among 13 bright stars of the O and B spectral type using the techniques of near-infrared bispectrum speckle interferometry, and then complemented these results with information about other known spectroscopic companions. In the speckle images, eight visual companions were found. Stellar masses of the companions were estimated from the
observed near-infrared flux ratios. After the survey was completed, general conclusions were drawn about the multiplicity of the massive O and B stars within the Orion Nebula Cluster. The average number of known companion stars in the survey of the 13 OB stars was 15/13 which indicates that there is 1.2 companions per primary star; however this number is considered low as there are undoubtedly more companions that are currently undetectable. Unless these massive stars as well as their companions move a good distance away from each other, a sizeable portion of the Orion Nebula has the makings of a very large cosmic fireworks show; as well as the potential for a large number of novae. Observation of the Orion Nebula is of course ongoing as star formation is still taking place. In conclusion, the Orion Nebula is a stellar nursery where stars are being born.
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Astronomy vs Astrology: A Science and a Study

Paul Zellner
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Professor Jenny Weitz
ABSTRACT:
This research paper aims to compare and contrast the topics of Astronomy and Astrology. After two months of research and consideration of both subjects, the outcome is that astronomy is truly a science and astrology is purely an entertainment tool. Comparing the two has proven to be difficult and informative as they are not as closely related as I first thought.

Astronomy is defined as the study of objects and phenomena originating beyond the Earth's atmosphere and is recognized as a science. The root word nomy refers to the rules, laws or knowledge aspect of the subject. The main purpose of astronomy is to examine and comprehend the how the universe works. Astronomers use the scientific method, naturalistic assumptions and math to investigate or explain what happens in the universe.

Astrology uses the positions of objects in the sky as a way of practicing pseudo-psychology, predicting the future, and a multitude of obscure and possibly false knowledge. It is not recognized as a science and is typically defined as a form of prophecy or divination. The root word logy refers to the study of the subject, which is stars and objects in the sky. Astrologers use mathematics to calculate the position of objects in the sky and try to correlate these events with happenings on Earth and human affairs. Astrologers use mystical or religious reasoning as well as traditional folklore, symbolism and superstition blended with mathematical predictions to explain phenomena in the universe.

This alone is enough to realize that only one of the subjects is recognized as a
“real” science. Astrology has long been rejected by scientists and has never been proven. Although once recognized as the same thing scientists around the seventeenth century began to split the two and reject astrology as a science.

Astronomy is one of the oldest natural sciences. Ancient astronomers were able to figure out that stars remained in relatively the same positions throughout time and discovered that planets would move. This aided in discovering that each was different and not everything in the sky was the same. Astronomers, in a multitude of civilizations used the motion of the objects in the sky as the to make early compasses, clocks and even calendars. Models were developed by astronomers to aid in creating these objects and to further study celestial objects.

In the 16th century Copernicus, an astronomer, discovered that the universe was heliocentric and not geocentric. By doing so he was able to explain the “looping” or retrograde motion of the planets. Other astronomers such as Kepler and Brahe were the start of modern astronomy in the 17th century. Kepler used Brahe’s measurements to develop his three rules, which still hold true today.

Other historic astronomers include Galileo and Newton who each contributed greatly to the field and development of Astronomy. Galileo taught heliocentrism, and developed a telescope which he used to study Jupiter’s moons and use them as a model for the solar system, among other things.

Newton built on earlier insights with his universal law of gravitation and its fruits: predictions or explanations of Kepler’s laws, the motion of comets, the shape of the Earth, tides, precession of the equinoxes and perturbations in the motion of planets which led to the discovery of Neptune. He also had to invent the mathematics to do this: calculus.
The creation of astrology can not be linked to just one civilization, as it widely believed that many practiced it separately of one another and because it is almost as old as mankind. The history of Astrology dates back to as early as 3,000 B.C. with the Babylonians and some believe it goes further back to about 5,800 B.C. Many other civilizations used astrology as it spread throughout the world including the Mayans, Indians and Chinese. It is believed to have made it’s way to Greece by 500 B.C. Arabic cultures of North Africa and the Eastern portion of the Mediterranean were using astrology in the 8th century. Albumasur, or Abu Maaschar (805-85 A.D.), wrote the Introductorium in Astronomiam and is credited with the revival of astrology in the Middle Ages. (AstZone)

Ptolemy, a Greek astronomer created what we know as the Zodiac today around 180 A.D. This circle of symbols aids to the modern form of astrology by using the signs as a way of explaining human beings and why they are the way they are. (Understanding) Many years ago astrology was recognized as similar and even the same as astronomy. This means that the funding that supported one also supported the other. As astronomy began to get more accurate astrologists developed a more detailed system in using the studies to represent it.

Astronomy and Astrology were at one time both combined as one discipline under the term Astrologia which was one of the original Seven Liberal Arts in Medieval Europe. (Astrology) Kings and other rulers generally employed court astrologers to aid them in the decision making in their kingdoms, thereby funding astronomical research. University medical students were taught astrology as it was generally used in medical practice.
It’s interesting to think that some of the most important astronomers of the past were recognized as astrologers by profession. This includes but is not limited to Tycho Brahe, Johannes Kepler, and Galileo Galilei.

These studies were used in the development of better timekeeping instruments, initially for aid in navigation; improved timekeeping made it possible to make more exact astrological predictions—predictions which could be tested, and which consistently proved to be false. Around the time that the scientific method came about astronomy distinguished itself as different from astrology because it could be tested and thus became a science and astrology became a study.

One common theme between Astronomy and Astrology though is the fact that all celestial objects are an integral part of the universe. However, astrologers philosophically and mystically portray the cosmos as having a supernatural, metaphysical and divine essence that actively influences world events and the personal lives of people. Astronomers, as members of the scientific community, cannot use in their scientific articles explanations that are not derived from empirically reproducible conditions, irrespective of their personal convictions.

On a Berkely website there is a page titled Understanding Science. One of the things found within this page are multiple answers that ultimately question whether or not Astrology should be seen as a science. Under the heading, “Do Researchers Behave Scientifically” is the following. Scientists don't wait for others to do the research to support or contradict the ideas they propose. Instead, they strive to test their ideas, try to come up with counterarguments and alternative hypotheses, and ultimately, give up ideas
when warranted by the evidence. Astrologers, on the other hand, do not seem to rigorously examine the astrological ideas they accept. As reflected by the minimal level of research in the field, they rarely try to test their arguments in fair ways. In addition, the astrological community largely ignores evidence that contradicts its ideas. (Berkeley)

There was also an experiment done by John McGrew and Richard McFall, who were in the Psychology Department at Indiana University, to test theories regarding Astrology and it’s validity. The experiment titled, “A Scientific Inquiry Into the Validity of Astrology” was published in the Journal of Scientific Exploration 1990. The goal of the study was to test six superior astrologers by having them match personal information, horoscopes and photographs. The results of the study showed that out of 23 subjects the astrologers could match no more than three. They did the same study and instead of astrologers, they had control subjects. These control subjects also got no more than three right. This study was used as proof that astrology is not a valid science as none of the astrologists could do what they said they could. (McGrew)

Astronomy and Astrology may have “grown up” together but as technology and information advanced it was clear these two were not quite the same. With Astronomy being based on real scientific priniciples and studies, it is still recognized as and respected as a science. This science has lead to discoveries and the advancement of what is known about the universe. Astrology was more of a belief that the movements of objects in the sky can affect people. Since the 20th century Astrology has morphed into an entertainment tool used to sell cheap advice and doesn’t aid to science in any way. These are clearly two different ways to view and use the universe.
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This source will be used to discover further differences between my subjects.


This source will be used to explain how scientists view astrology and if it is truly considered a science based on the details.

This source will be one of the scientific journals I will use to discover further information.


This is a scientific journal which delves further into Astrology and its place in science.


This publication will give a more detailed overview of astronomy.


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