How Hitler Influenced Mathematics

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Figure 1: Adolf Hitler[19]

Abstract

Adolf Hitler pushed German scientists to search out new technology, and forced a world wide arms race. Scientists both in Germany and around the world tried to push the envelope of new ideas. These new ideas brought about new horrific tools of war, the jet age, and the rocket age. Some scientists felt the force of Hitler personally, especially those of Jewish descent. Some of these scientists emigrated to the United States and Britain to escape the Holocaust. In this paper I will discuss Hitler's personal view of mathematics, some of the technologies that were researched during World War II, and some of the scientists and mathematicians who fled Germany and Western Europe at that time.

1 Introduction

Adolf Hitler had an interesting background. As a teenager he could be considered a "starving artist" because most of the people who have seen his paintings did not like them. He was turned down twice for the Academy of Fine Arts Vienna due to his poor artistic talent. After World War I ended, Hitler joined the political scene while drinking in a bar. He joined a group that was discussing the current political scene in Germany. Hitler explained his opinion and blamed the Jews for Germany's problems after World War I. According to Hitler, the Jewish government officials handed Germany over to the people who destroyed it during the war with the Treaty of Versailles. Hitler realized that he had the power of persuasion, and a knack for public speaking. Starting in bar room discussions, Hitler gained the respect and hearts of the German people. With his rise to power, Hitler began to push his own agenda. He was appointed Chancellor five years after being released from prison for his attempt to overthrow the reigning government. While Chancellor he remilitarized Germany, going against the Treaty of Versailles.

1.1 Geometry vs. Algebra

Since Hitler was an artist before he was a leader in the Nazi party, his love of art probably influenced a turn towards geometry instead of algebra in German schools.[13] Hitler was in power for twelve years, therefore, his ideas effected an entire generation of students directly. Since geometry better described how the world appears than algebra, the need to push algebra was not as critical. The idea that geometry was the best way to describe how the world worked was not new to Hitler. Isaac Barrow, a 17th century mathematician, also believed that geometry was the basis for science and mathematics.[23] Ironically, the technology that Hitler desired required algebra, calculus, and differential equations. Comparatively, seeing the world in a geometric mindset, rather than an algebraic, stifles the ability of computations.

2 New Technologies

War brings a need for new technologies. Hitler used awards to replace the Nobel Prize, since German scientists were no longer allowed to receive the Nobel Prize. "Many German academics, scientists, and technicians had been members of the Nazi Party, often because party membership brought benefits such as research grants and promotions. The Party often bestowed honorary rank as a reward."[5] These and other incentives were given to increase the rate of developing new technologies. Scientists working for the Nazi party could receive resources that would not otherwise be available, this coupled with not invoking the wrath of the Third Riech or the SS. "Germany had become the first nation in the world to develop and use jet fighters (Me-262s), cruise missiles (V-1s), and ballistic missiles (V-2s)."[1] This required a great deal of mathematics, as will be discussed in later sections.

2.1 German Atomic Bomb

Rumors of “extremely powerful bombs”[1] that use a “nuclear chain reaction”[1] to develop an extreme amount of energy circled the globe. These rumors came from a very credible source, Albert Einstein. “Fission, the basic process that makes nuclear weapons possible, was first discovered in Berlin in December 1938. Though the beginning of the war was still ten months away, when news of the German discovery arrived in the United States, it caused a considerable amount of alarm. Not only did it now appear for the first time that an “atomic bomb” was possible, but it was Nazi Germany that seemed to be ahead in this new and potentially worst-of-all arms races.”[1] An arm race started by a man with intentions of world domination, and the extermination of an entire race of people. Much like the American scientists, the German scientists saw the bomb as a way of ending the war, and ending it victoriously. The mathematics will be discussed in later sections.

2.2 German Rocketry

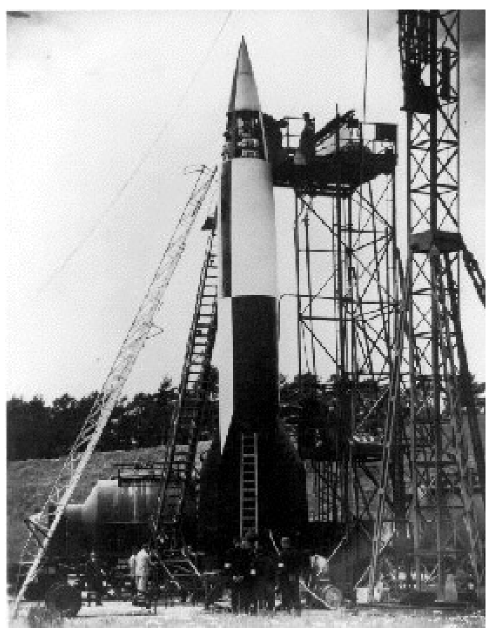

Figure 2: A V-2 (A-4) on a test stand at Peenemunde, Germany, during the war. The high, arching flight of the V 2 carried it to an attitude of about 100 miles.[22]

Wernher Von Braun joined the German rocket society in 1929. He later developed ballistic missiles for the German army after 1932. “Von Braun is well known as the leader of what has been called the “rocket team which developed the V2 ballistic missile for the Nazis during World War II. The V2s were manufactured at a forced labor factory called

Mittelwerk."[4] The V-2 used a liquid propellant to fly over "3,500 miles per hour and deliver a 2,200 pound warhead to targets as far as 500 miles away." The term V-2 came from Hitler, meaning "Vengeance Weapon 2" because it wreaked vengeance upon a helpless population.[22] The V-2 was suggested for space travel by Von Braun himself. Von Braun worked in the Hitler regime until the end of the war, when he migrated to the United States and became a part of National Aeronautics and Space Administration(NASA). When at NASA, Von Braun helped develop the first rockets used for space travel. These rockets were very similar to the V-2. Like Goddard, Von Braun used calculus to describe the motion of rockets. Since the mathematics in German Rocketry and U.S. rocketry are the same, we will discuss the math and Goddard in section 3.2.

3 The rest of the world

With the German war machine seeking new technologies, such as the atomic bomb, and obtaining technologies such as jet power, rocketry, and large howitzers, the rest of the world would have to find a way to compete with the new German weapons. Incentives such as the Nobel Prize, government grants, and the possibility of world peace gave motivation for the scientists around the world to increase the science output.

3.1 Manhatten Project

"For most of the Second World War, scientists and administrators of the Manhattan Project firmly believed that they were in a race with Germany to develop the atomic bomb. As it turns out, the German atomic program did not come close to developing a useable weapon. Allied planners were only able to confirm this, however, through the ALSOS intelligence mission to Europe toward the end of the war. Atomic research was also conducted in Japan, but as was suspected by the Allies, it did not get very far." The arms race between the great powers of the world was in full swing. Each country needed the weapon that could end the war, and prevent future wars. The atomic bomb was thought to be a weapon whose mere existence would bring peace to the world that had been plagued by war. What country would get the bomb, and to what extent would it be used? The scientific community in the free world knew that Germany had learned to make heavy water, and the secrets to a nuclear reaction. With the possibility of atomic power in the hands of the Nazis, the leaders of the free world must be warned. "Many of the scientists that took a leading role in alerting the United States government to this danger, such as Albert Einstein, Enrico Fermi, and Leo Szilard, were recent migrs from Europe who felt the threat from Nazi Germany especially acutely."[1]

The basic idea of an atomic reaction starts with the conservation of energy. Since energy can neither be created or destroyed, an incident particle x, reacts on a nucleus X,

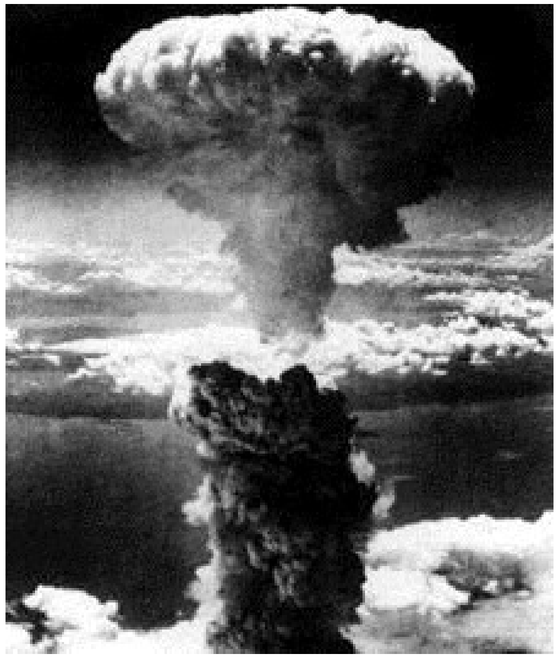

Figure 3: An Atomic Bomb test.[21]

resulting in a nucleus Y, and a particle y, and energy Q. When solved for Q,

$$Q = (m_x + m_X - m_y - m_Y)c^2,$$

where c is the speed of light. This creates an exothermic reaction when the mass of the initial particles is more than the mass of the resulting particles. Fission releases several neutrons, allowing more reactions. This creates a chain reaction, creating more energy with each step in the chain. For any fission reaction, there is a critical energy that must be achieved before fission will take place. When the critical energy is reached, the nuclear potential instantly moves from zero to a large nuclear reaction, and separating the particles. This allows the particles to react again, and again, each time increasing the energy expelled.[15] Enrico Fermi had an acute understanding of these reactions, as will be discussed in a later section.

"On July 16, 1945, an implosion bomb was successfully tested near Alamogordo, New Mexico. The production of this bomb, and its gun-type counterpart, ushered in the atomic age. The development of these weapons represented the culmination of more than three years of intense research and development effort. At Los Alamos, science and technology combined to produce a weapon of incredible power; enough even to end the most destructive war in history"[10] Although there were and are still moral questions to the use of atomic, hydrogen, and nuclear bombs, at the time the bomb was seen as a means to an end. The debate continues today. Who should have weapons that destroy entire cities? The incredible arms race started by Hitler continues still, but the countries involved have changed several times.

3.2 American Rocketry

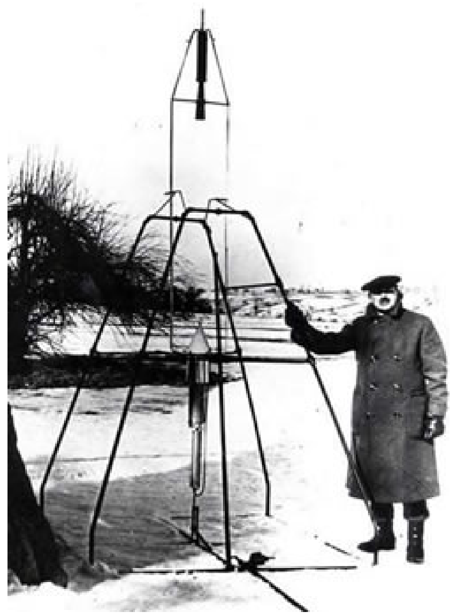

Figure 4: Robert Goddard with an early experimental rocket.[18]

Robert Goddard is known as the father of American rocketry.[2] Although he began his work before the rise of Hitler, Goddard's work was mimicked by the Germans. "Goddard's work largely anticipated in technical detail the later German V-2 missiles, including gyroscopic control, steering by means of vanes in the jet stream of the rocket motor, gimbal-steering, power-driven fuel pumps and other devices."[3] Goddard used a complex interconnecting mesh of formulas to map out the path of the rocket and the forces needed to move the rocket.

Rockets burn fuel to create lift. This decreases the mass of the rocket, and makes the force necessary to continue accelerating upward decrease as well. At the time the rocket engines are started, $t = 0$, the mass of the rocket is dependent on time. $M(t) = (m_f + m_r) - bt$, where m_f is the initial mass of the fuel, m_r is the mass of the rocket, and b is the burn rate of the rocket motor. To minimize the lift needed, the mass of the rocket and the mass of the fuel must be minimized. However, the rocket engine must create enough lift to propel the rocket to the desired altitude. The efficiency of any engine, is the ratio of the input of energy into the engine, usually by the way of fuel, and the amount of work the engine can do with that energy. one should note that a perfectly efficient engine only works in theory, and the laws of thermodynamics and friction restrict engine efficiency. Goddard's rocket engine design had an efficiency of 63 percent. This is far more efficient than most engines, including steam at a maximum of 21 percent efficiency and diesels at 40 percent efficiency. A more efficient rocket motor would have a lower burn rate and allow less fuel to be used to reach a given altitude. So a balance of thrust and efficiency must be found.

The equation for thrust is

$$F_{\text{thrust}} = m_{\text{fr}} V_e + (p_e - p_o) A_e,$$

where m_{fr} =mass flow rate, V_e =exit velocity, p_e =exit pressure, p_o = outside or atmospheric pressure, and A_e = area of the exhaust. This means that the efficiency of the rocket is a function of the exhaust pressure, the area of the rocket, and flow rate of the propellent. A larger area of the rocket would allow a greater force, but must be matched by a pressure. Decreasing the area of the rocket would decrease the force, unless matched with a greater exit pressure. In like manner, decreasing the mass flow rate would decrease the force, unless matched with a greater exit velocity. The thrust created by the motor must be greater than the initial mass of the rocket, so

$$F_{\text{thrust}} > m_f + m_r.[7]$$

Rockets move on a parabolic curve. The position of the rocket vertically is given as:

$$p_y = (1/2) a_y t^2 + v_y t.$$

The horizontal position is given as:

$$p_x = (1/2) a_x t^2 + v_x t,$$

where p is position, a is acceleration, t is time starting at t=0, v is velocity, x gives the horizontal component, and y gives the vertical component. Taking the derivative of the above equations, the velocity of the rocket is found.

$$V_y = a_y t,$$

$$V_x = a_t.$$

Taking the derivative again, the acceleration of the rocket is found, and using the definition of force, we have:

$$a_y = F_y / m,$$

$$a_x = F_x / m.$$

The combination of the above equations, put into practice gave a great fireworks show for many early rockets around the world. Many rockets did not get far from the launch pad. Rockets were considered too unstable to use as accurate weapons until the 1920's and later. Today we see the near perfection in successful launches of rockets from space agencies in multiple countries, ballistic missiles, and even rockets that can be fired from the shoulder of infantrymen. The research done during World War II helped bring the human race into the rocket age.

3.3 Operations Research

England has many tactical disadvantages during war, due to its location. One disadvantage is the lack of a large supply of natural resources to produce the tools of war. When this is combined with the different tactics of fighting a war, the solutions become quite complex. During World War II a new branch of math was born, operations research. The questions of what resources should be used for producing which machine, ammunition, plane, tank, etc. would be answered by calculations instead of guessing. British scientists wanted to make these decisions based on scientific facts. This branch of math takes into consideration the alternative decisions that could be made, the restrictions on the decisions that are made, and the appropriate objective criterion for evaluating the alternatives.

Consider an ammunition factory, where two types of ammunition are made, one for rifles, and one for pistols. Which ammunition should be made in greater quantity, or should equal amounts of each ammunition be made? If the pistol ammunition takes less time and less resources to make than the rifle ammunition, then the decision seems easy. Consider, though, when and how often will each ammunition be used. Are the troops in close enough encounters on an often enough basis to manufacture more pistol ammunition? What ammunition leaves the supply depots in greater quantity? These are only a few of the considerations that could be taken into account in this problem.

After the parameters are established, they are set into an equation, and then maximized or minimized depending on the need. Finding the maximum or minimum of an equation is a calculus problem. This is much more effective in decision making than just guessing and looking for the results. "After the war, the ideas advanced in military operations were adapted to improve efficiency and productivity in the civilian sector."[14] This seems like a simple enough idea, but it was an idea that was unrecognized until the time of Hitler.

4 Moving scientists

There were millions that were killed in concentration camps, and in the war itself. Many of those who died were civilians. With all of Europe engulfed in fighting, and German U-boats attacking ships leaving Europe, fleeing was a risky option, and not an option for millions. There is a great possibility that some of those people could have influenced mathematics as well. Some people did have the great fortune to leave Europe and move to other parts of the world. Many great minds, like Paul Erdös, Albert Einstein, and Enrico Fermi claimed

Eastern Europe as home. These men and their families left the racial discrimination of Hitler's regime and moved to the United States.

4.1 Paul Erdös

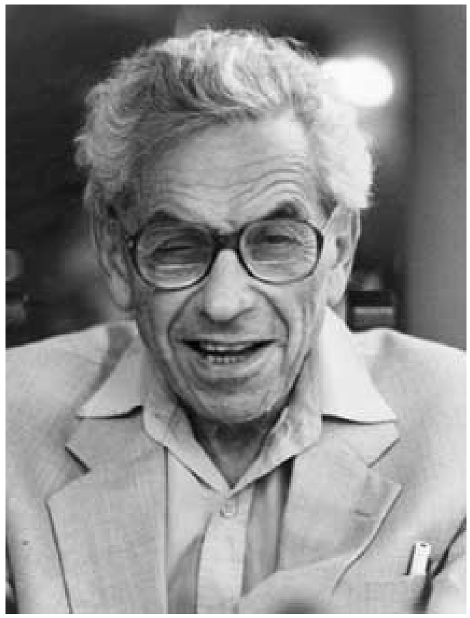

Figure 5: Paul Erdös[17]

Paul Erdös is considered one of the greatest mathematicians of all time. His following is so great that everyone who is published has an Erdös number, the number of people who can be counted between what that person has published, and a paper published by Erdös. The tracking is not very difficult since Erdös has published a plethora of papers with many different coauthors. Erdös was born in Hungary, and moved to England before migrating to the United States in 1938. "In 1949, the Norwegian mathematician Atle Selberg (1917-) and the Hungarian mathematician Paul Erdös (1913-96) discovered an elementary proof of the prime number theorem. In 1950, Selberg received the prestigious Fields Medal for this work. As a measure of difficulty, consider that in 1950, the author of this book attended a course of about 30 lectures devoted to an exposition of the new "elementary" proof of the prime number theorem." [12]

4.2 Albert Einstein

"In 1914 he was appointed Director of the Kaiser Wilhelm Physical Institute and Professor in the University of Berlin. He became a German citizen in 1914 and remained in Berlin

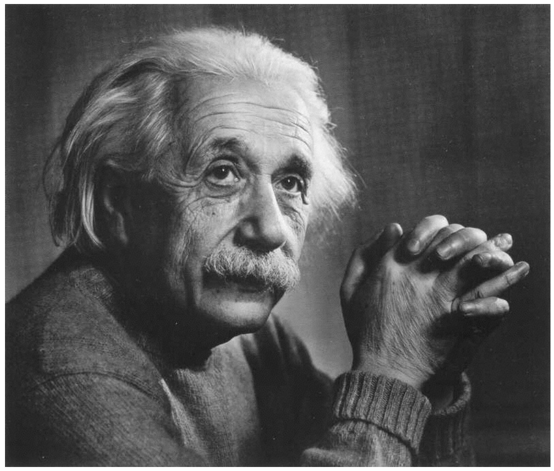

Figure 6: Albert Einstien[20]

until 1933 when he renounced his citizenship for political reasons and emigrated to America to take the position of Professor of Theoretical Physics at Princeton".[8] Being Jewish himself, Einstein felt a need to flee the Nazi anti-semitism. Even though he came to the United States after his greater achievements, such as his work on electrodynamics of moving bodies, where he postulated a general principle of relativity, Einstein was an asset to the American scientific community. In 1905, Einstein published this work along with others. Special relativity was also derived, using only two postulates:

1. The laws of physics are the same in all inertial reference frames.

2. The speed of light in a vacuum is equal to the value c, independent of the motion of the source.

The first postulate explains that regardless of the bounds of an inertial system, the physics measured in that system will be the same. This is an improvement on Newtonian idea which only include measurements and mechanics. The second postulate states that the speed of light is independent of the speed of the object emitting the light. The speed of light is then a constant, and given the value c. Since the speed of light is constant, as an object approaches the speed of light, there is a shift in time perception and length perception.

This understanding is a great achievement, considering the current concept of speed. Particle accelerators now can propel electrons, protons, and neutrons very close to the speed of light, however, the fastest man made vehicle, flying over 36,000 miles per hour, is far from matching the speed of light. With these works completed earlier in his lifetime, Einstein continued to improve our understanding of how math and science works by searching for a true unified field theory until his death in 1955.[15]

4.3 Enrico Fermi

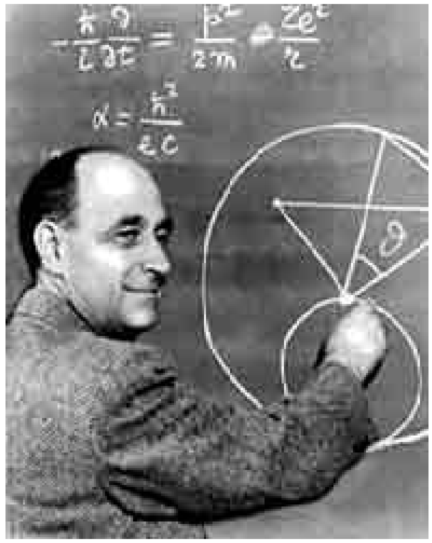

Figure 7: Enrico Fermi[16]

Enrico Fermi started his career in Rome, where he evolved the Beta-decay theory, and neutron bombardment. Neutron bombardment is where neutrons are accelerated to a very high speed and directed at an atom, making the atom and neutron collide. The atom will release particles and energy. Fermi moved to the United States in 1938 to escape the prejudice of Hitler. "Upon the discovery of fission, by Hahn and Strassmann early in 1939, (Fermi) immediately saw the possibility of emission of secondary neutrons and of a chain reaction. He proceeded to work with tremendous enthusiasm, and directed a classical series of experiments which ultimately led to the atomic pile and the first controlled nuclear chain reaction."[9] Fermi led the group that "produced the first self-sustaining chain reaction in a nuclear reactor that they had constructed at the University of Chicago."[15] When Fermi was a part of the scientists that warned the president of the possibility of Germany creating an atomic bomb, he knew what he was talking about. Fermi continued in the development of nuclear reactions, and explored the use of nuclear reactions as a use of power. After World War II ended, Fermi became a professor at the Institute for Nuclear Studies of the University of Chicago, and remained there until his death in 1954. While there, Fermi studied the origin of cosmic rays, and developed a theory of a "universal magnetic field - acting as a giant accelerator - would account for the fantastic energies present in the cosmic ray particles."[9]

5 Conclusion

This is only a part of the mathematics and science that was studied during the World War II era. At this time calculations were key, and failure was not an option, for either the scientists under Hitler, or the scientists who were working to stop him. Because of Hitler, the human race entered the Atomic Age, the Rocket Age, and an age where calculations became a part of everyday life for more than just the mathematicians. The idea of mathematical and scientifical brainpower shifted from Europe to the rest of the world. World War II is a horrible time in world history, however, some good did come from the war.

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