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## Gamma rays from nuclear propulsion annihilation of matter

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### Abstract

In this paper we are going to explain how gamma rays from nuclear propulsion systems can be used up by the space vehicle itself in a very useful and effective manner. It is known to us that gamma rays can annihilate matter in its lower stage of fundamental building blocks like electrons and protons. Now, we all as engineers must be knowing that space vehicles are powered by thrusters to move around in outer space. When we are able to produce electron-proton pair by the emission of gamma rays. Then why not we use this energy to power the thrusters used along with nuclear propulsion technology.

**Keywords:** nuclear propulsion, gamma rays, ion thrusters.

### 1. Introduction

It is known to us that people have started to wander out in space for various research purposes and have set milestones in the field of space technology and astronomy. So, here is the need of better technological developments in this field as the experts here are inventing and discovering things at a very rapid rate. This is where we wish to introduce our concept based on the technology of nuclear propulsion in space ships. One such project is the project Orion, where the ship is nuclear powered. Now we all must wondering what happens to the gamma rays that are being emitted by the nuclear reactions taking place. This is where we intend to introduce our concept of gamma rays powered ion thrusters which make use of the energy of the gamma rays emitted by the nuclear reactions. So, we all know that gamma rays is one of the rays with highest destructive power. So, we are going to make use of this annihilating power in a very effective and efficient manner. So, now we shall go deep into the topic and see about the concept proposed by us.

### 2. Gamma rays

Gamma radiation, also known as gamma rays, and denoted by the Greek letter  $\gamma$ , refers to electromagnetic radiation of an extremely high frequency and are therefore high energy photons. Gamma rays are ionizing radiation, and are thus biologically hazardous. They are classically produced by the decay of atomic nuclei as they transition from a high energy state to a lower state known as gamma decay, but may also be produced by other processes. Paul Villard, a French chemist and physicist, discovered gamma radiation in 1900, while studying radiation emitted from radium. Villard's radiation was named "gamma rays" by Ernest Rutherford in 1903. Natural sources of gamma rays on Earth include gamma decay from naturally occurring radioisotopes, and secondary radiation from atmospheric interactions with cosmic ray particles. Rare terrestrial natural sources produce gamma rays that are not of a nuclear origin, such as lightning strikes and terrestrial gamma-ray flashes. Additionally, gamma rays are produced by a number of astronomical processes in which very high-energy electrons are produced, that in turn cause secondary gamma rays via bremsstrahlung, inverse Compton scattering and synchrotron radiation. However, a large fraction of such astronomical gamma rays are screened by Earth's atmosphere and can only be detected by spacecraft. Gamma rays typically have frequencies above 10 exahertz (or  $>10^{19}$  Hz), and therefore have energies above 100 keV and wavelengths less than 10 picometers ( $10^{-12}$  meter), which is less than the diameter of an atom. However, this is not a hard and fast definition, but rather only a rule-of-thumb description for natural processes. Gamma rays from radioactive decay are defined as gamma rays no matter what their energy, so that there is no *lower* limit to gamma energy derived from radioactive decay. Gamma decay commonly produces energies of a few hundred keV, and almost always less than 10 MeV. In astronomy, gamma rays are defined by their energy, and no production process need be specified.

The energies of gamma rays from astronomical sources range to over 10 TeV, an energy far too large to result from radioactive decay. <sup>[1]</sup> A notable example is extremely powerful bursts of high-energy radiation referred to as long duration gamma-ray bursts, of energies higher than can be produced by radioactive decay. These bursts of gamma rays, thought to be due to the collapse of stars called Hypernovae, are the most powerful events so far discovered in the cosmos. <sup>[2]</sup>

### 3. Annihilation of matter

Annihilation is defined as "total destruction" or "complete obliteration" of an object; <sup>[3]</sup> having its root in the Latin *nihil* (nothing). A literal translation is "to make into nothing". In physics, the word is used to denote the process that occurs when a subatomic particle collides with its respective antiparticle, such as an electron colliding with a positron, illustrated here. <sup>[4]</sup> Since energy and momentum must be conserved, the particles are simply transformed into new particles. They do not disappear from existence. Antiparticles have exactly opposite additive quantum numbers from particles, so the sums of all quantum numbers of the original pair are zero. Hence, any set of particles may be produced whose total quantum numbers are also zero as long as conservation of energy and conservation of momentum are obeyed. When a particle and its antiparticle collide, their energy is converted into a force carrier particle, such as a gluon, W/Z force carrier particle, or a photon. These particles are afterwards transformed into other particles. <sup>[5]</sup> During a low-energy annihilation, photon production is favored, since these particles have no mass. However, high-energy colliders produce annihilations where a wide variety of exotic heavy particles are created. <sup>[6]</sup>

### 4. Ion thrusters

An ion thruster is a form of electric propulsion used for spacecraft propulsion that creates thrust by accelerating ions. The term is strictly used to refer to gridded ion thrusters, but may often more loosely be applied to all electric propulsion systems that accelerate plasma, since plasma consists of ions. Ion thrusters are categorized by how they accelerate the ions, using either electrostatic or electromagnetic force. Electrostatic ion thrusters use the Coulomb force and accelerate the ions in the direction of the electric field. Electromagnetic ion thrusters use the Lorentz force to accelerate the ions. In either case, when an ion passes through an electrostatic grid engine, the potential difference of the electric field converts to the ion's kinetic energy (in the reference frame of a spacecraft). According to Edgar Choueiri ion thrusters have an input power spanning 1–7 kilowatts, exhaust velocity 20–50 kilometers per second, thrust 20–250 milliNewton and efficiency 60–80%.<sup>[7, 8]</sup> The Deep Space 1 spacecraft, powered by an ion thruster, changed velocity by 4.3 km/s while consuming less than 74 kilograms of xenon. The Dawn spacecraft has surpassed the record with 10 km/s

<sup>[7, 8]</sup>. The applications of ion thrusters include control of the orientation and position of orbiting satellites (some satellites have dozens of low-power ion thrusters) and use as a main propulsion engine for low-mass robotic space vehicles (for example Deep Space 1 and Dawn).<sup>[7, 8]</sup> Ion thrusters are not the most prospective type of electrically powered spacecraft propulsion (although in practice they have worked out more than others).<sup>[8]</sup> Technical capabilities of the ion engine are limited by the charge created by ions, that limits the density thrust (force per cross-sectional area of the engine) at a very small level.<sup>[8]</sup> Therefore ion thrusters create very small levels of thrust (for example thrust engine Deep Space 1 approximately equals the weight of one sheet of paper<sup>[8]</sup>) compared to conventional chemical rockets but achieve very high specific impulse, or propellant mass efficiencies, by accelerating their exhausts to very high speed. However, ion thrusters carry a fundamental price: the power imparted to the exhaust increases with the square of its velocity while the thrust increases only linearly. Normal chemical rockets, on the other hand, can provide very high thrust but are limited in total impulse by the small amount of energy that can be stored chemically in the propellants.<sup>[9]</sup> Given the practical weight of suitable power sources, the accelerations given by ion thrusters are frequently less than one thousandth of standard gravity. However, since they operate essentially as electric (or electrostatic) motors, a greater fraction of the input power is converted into kinetic exhaust power than in a chemical rocket. Chemical rockets operate as heat engines, hence Carnot's theorem bounds their possible exhaust velocity. Due to their relatively high power needs, given the specific power of power supplies, and the requirement of an environment void of other ionized particles, ion thrust propulsion is currently only practical in space. <sup>[10]</sup>

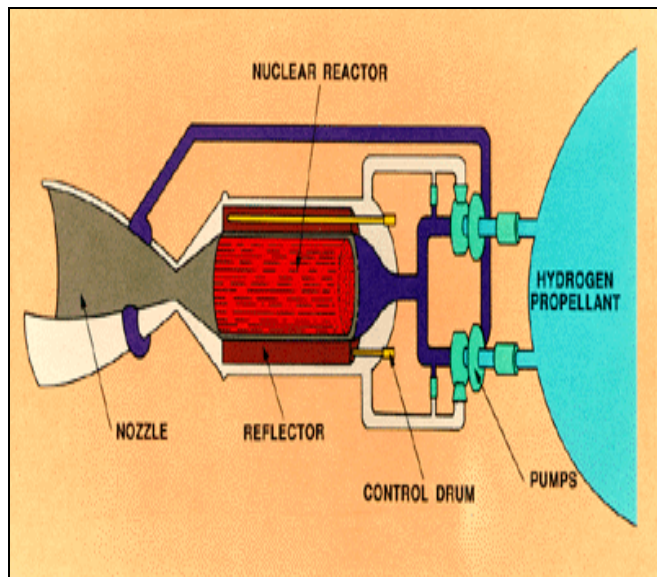
### 5. Nuclear propulsion

Nuclear propulsion includes a wide variety of propulsion methods that fulfill the promise of the Atomic Age by using some form of nuclear reaction as their primary power source. The idea of using nuclear material for propulsion dates back to the beginning of the 20th century. In 1903 it was hypothesized that radioactive material, radium, might be a suitable fuel for engines to propel cars, boats, and planes. <sup>[11]</sup>

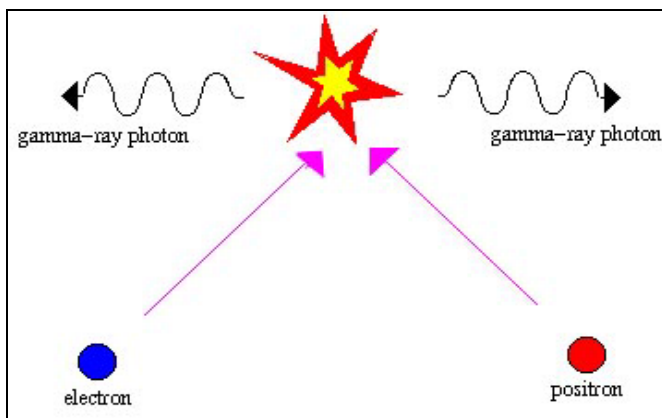
### 6. The concept

This concept is based on the fact that annihilation of matter takes place when gamma rays are focused on any matter. So, why not we take advantage of this property of gamma ray especially the ones emitted from the nuclear reaction that is a part of the nuclear propulsion in rockets. So, there will be no emission of harmful gamma rays as before as it used up for the annihilation of matter i.e., the matter can be broken into electrons and protons which can be used for powering the ion thrusters and even neutralizing the ions emitted by the neutralizers. One such experiment is the project Orion, which is nuclear, powered. So, we suggest this concept for projects' like the project Orion.

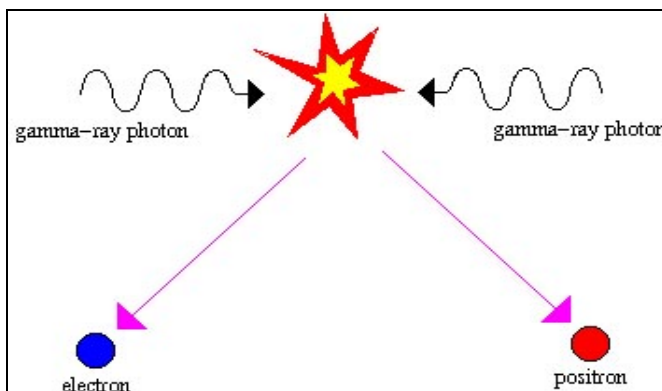
**Diagram**



Nuclear Reaction Taking Place [13]



Production of Gamma Rays [14]



Annihilation of Matter [14]

**7. Definitions**

**7.1 Fission**

In nuclear physics and nuclear chemistry, nuclear fission is either a nuclear reaction or a radioactive decay process in which the nucleus of an atom splits into smaller parts (lighter nuclei). The fission process often produces free neutrons and photons (in the form of gamma rays), and releases a very large amount of energy even by the energetic standards of radioactive decay. [15]

**7.2 Fusion**

In nuclear physics, 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. During this process, matter is not conserved because some of the matter of the fusing nuclei is converted to photons (energy). Fusion is the process that powers active or "main sequence" stars. [16]

**7.3 Gamma rays**

Gamma rays have the smallest wavelengths and the most energy of any wave in the electromagnetic spectrum. They are produced by the hottest and most energetic objects in the universe, such as neutron stars and pulsars, supernova explosions, and regions around black holes. On Earth, gamma waves are generated by nuclear explosions, lightning, and the less dramatic activity of radioactive decay. [17]

**7.4 Propulsion**

Propulsion is a means of creating force leading to movement. A propulsion system has a source of mechanical power (some type of engine or motor, muscles), and some means of using this power to generate force, such as axles, propellers, a propulsive nozzle, wings, fins or legs. [18]

**7.5 Thrusters**

A thruster is a propulsive device used by spacecraft and watercraft for station keeping, attitude control, in the reaction control system, or long-duration, low-thrust acceleration. [19]

**7.6 Advantages**

This concept has the following advantages:

The emission of gamma rays does not create any problem due to its exposure.

The nuclear reaction can run as this system takes care of the exposure continuously.

This can also serve as an auxiliary power system for the spacecrafts.

**8. Conclusion**

Thus, we have come across an innovative way to use up the gamma rays emitted during the reaction process. The scope of this paper mainly lies in the field of nuclear physics and space technology.

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