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ENERGY EXTRACTION FROM PRIMARY COSMIC RADIATION

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ABSTRACT

The key purpose of the process is to provide an alternate efficient source of energy, water and oxygen, using the resources available in space, thereby promoting space travel.
The main idea is to use the high energy primary cosmic rays as a source of alpha particles, and use them for nuclear transmission of Nitrogen-14 to Oxygen-17 and Hydrogen (protium). This Hydrogen, which has a very high calorific value, can further be used as a raw material for generating energy, and oxygen can also be used by humans for respiration. The whole setup can be attached to the space shuttle itself as well.

I. INTRODUCTION

Since the existence of the cosmic rays has been proven, there has been a lot of activity in this area. Studies in the field have suggested that we receive are regular shower of cosmic rays due explosive events on sun (like the solar flares), stars, but majorly from the supernovas.

Supernova essentially means the death of a star. While a star runs out of fuel (Hydrogen), the gravitational force increases due to formation of heavy atoms in the nuclear fusion reaction, and the star to collapse, eventually leading to a huge blast. The cosmic rays area result of that same explosion.

Cosmic radiation that reaches us has a great potential for energy extraction, but we haven't been able to find a way to harness that energy efficiently yet.

There is no better time than now. [1] In an article, NASA stated that their Advanced Composition Explorer (ACE) spacecraft has detected good amounts of radioactive iron nuclei in the cosmic rays. Iron-60 is actually created inside a star and blasted off with cosmic rays during the supernova. Although it travels at about half the speed of light, it doesn't go too far on a galactic scale. Iron-60 is a charged species, so it is forced to take convoluted paths due to the varying magnetic fields from all kinds of sources in space. Also, it is a radioactive species, and half of it is expected to decay into Cobalt-60 and then Nickel-60during a period of 2.6 million years. Despite this fact, 300,000galactic cosmic rays of ordinary iron and 15 of the radioactive Iron-60 has been detected by the ACE in 17 years. The number of the radioactiveiron-60 rays looks small, but the fact that they were even detected is a big deal. It implies that the cosmic rays we receive were created quite recently (around1millionyears) and that the source was fairly close (about 3000 light years). These numbers may look large, but they are relatively small on an astronomical scale, considering the fact that there are billions of stars are present in our Galaxy, which is about100, 000 light years wide. Thinking about using the energy of the radiation directly might seem illogical due to small output. The energy of cosmic rays striking the Earth is about 5 joules/sec/km2 (1joule/sec=1watt), which means that if energy was collected over a 12 square kilometer area, it would only be enough to power a 60 watt light bulb.

[2]Nuclear transmutation was a phenomenon first observed by Sir E. Rutherford and Frederick Soddy in the year 1901, when they were doing experiments involving collision of light atoms with alpha particles .In this phenomenon, sometimes when atoms collide, their nucleus fuse together and form heavier atoms with a bigger nucleus. This opened up a great number of possibilities for the production of atoms of desired rare elements by combining together smaller and more abundant atoms.

Using these two revolutionary ideas, I have designed a process which can act as a clean and available energy source.

II. MATERIALS AND METHODS

The first step is responsible for converting the human fecal matter into ammonia through the artificial ammonification process.

This ammonia is used in the reverse Haber's process under high temperature and pressure, and we get Nitrogen and Hydrogen gas. The Hydrogen gas can be easily adsorbed using a suitable adsorbent material like Nickel chips, which will be desorbed later. The Nitrogen is transferred to another chamber where it will be bombarded with Alpha particles (doubly charged Helium ions).The main objective of this first step is to use the astronaut's waste material, which otherwise just piles up, and is eventually disposed into space. So here we are not only getting the required Nitrogen gas, but we are also utilizing the waste material, thereby reducing space junk.

Now, the primary cosmic rays are used as a source of alpha particles. 9-10% of Cosmic rays consist of high-energy alpha particles. These can be filtered out of cosmic rays by using a modified mass spectrometer. The opening is covered by two plates with slits such that the slits in the second plate are perpendicular to the slits in the second plate (as shown in figure 1). The slits help to ensure that the cosmic are rays are parallel and their angle with the central plane is 0 degrees (requirement for proper functioning of a mass spectrometer). Now, as we know the charge as well as the mass of alpha particles, we can easily predict the radius and hence the path of these helium ions, which is determined by their q/m ratio (-3.650 e+3).Their q/m ratio and hence the deviation is not close to that of the other components of cosmic rays, so they can be filtered with somewhat ease.

These particles are then directed to the chamber with Nitrogen gas and bombarded with the gas particles. This results in a [2] nuclear transmutation reaction in which the nitrogen atoms are converted into Hydrogen (protium isotope) atoms andOxygen-17 atoms.

If we compare the bond energies of the possible combinations of these two atoms [4,5] H- H is 432 kJ/mol, O2 is 495 kJ/mol and O-H is 467 kJ/mol), we see that all three molecular compounds will be formed in approximately equal proportions.

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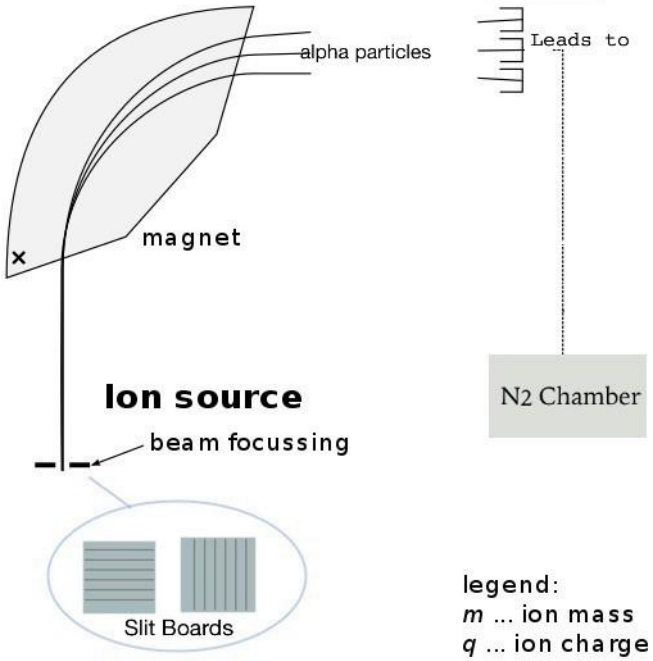

Figure 1: Alpha particle filtration from cosmic rays

Table 1. Bond Energy Table

Compound	Bond Energy
O-O	495 kJ/mol
O-H	467 kJ/mol
H-H	432 kJ/mol

The Hydrogen molecules are desorbed at this point from the Nickle chips by heating them at high temperatures. It is then added to the mixture of products obtained from the nuclear transmutation reaction. The hydrogen gas is combusted in presence of O2.Using is it in the fuel cells for energy production like in the Apollo space mission is one possible way to go about. Hydrogen has a very high calorific value and the energy generated can be used to power the space shuttle. The product is just Water but with O17 molecule. The important point is the O17 is [6] relatively stable and fit for human consumption, hence the H2O17 can used by us while space travel.

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Ammonification

$$\text{Human faeces} \longrightarrow NH_3$$

Haber's Process

$$2NH_3 \rightleftharpoons N_2 + 3H_2$$

Rutherford Equation (nuclear transmutation)

$$N^{14} + He^{2+}\ (\text{alpha particle}) \longrightarrow O^{17} + H^{1}$$

Combustion

$$H_2 + 1/2\ {}^{17}O_2 \longrightarrow H_2O^{17}$$

Figure 2: The process at a glance

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III. DISCUSSION

This process revolves primarily around the nuclear reactions. For considering the output and practicality of these type of reactions, some factors like the [7] cross section (unit - barn) and the number of effective collisions are taken into account in particle physics. In a favorable situation 5000–9000collisionspersecond occur. If we see in a year, there are 3.154 e+7 seconds, and hence in the best case scenario 9000 * 3.154 e+7 = 2.8386 e+11. In our case1mole (approx6.023e+23) collisions are necessary for the production of 14 grams of Nitrogen. Clearly the best case scenario can only produce 6.5981073e-12 grams of Nitrogen. This is negligibly small.

$365 \times 24 \times 3600 = 3.154 \times 107$ seconds (in 1 year)

$(9 \times 103) \times (3.154 \times 107) = 2.8386 \times 1011$ collisions (in 1year)

$[\ (2.8386 \times 1011) \div (6.023 \times 1023)\ ] \times 14 = 6.5981073 \times 10{-}12$ grams (in 1 year)

Despite the free approximations to slightly exceed the real values, considering favorable conditions, the numbers tell that output is not as much as expected. One could argue that Even if we try to concentrate the particles and the cosmic rays in a smaller space/region, it would not help a lot. The size of the nucleus of the particles we are dealing with is small that all these techniques, which we use on a macroscopic scale, have a little to no effect on the collision frequency.

IV. CONCLUSIONS

The main problem that the current space agencies are facing is the provision of adequate amounts resources. It is quite obvious that if we were to travel to farther reaches of the universe we would need a much better life support system. For starters, energy, water and oxygen are some of the most basic and essential needs.

In conclusion, this process taps into the potential of cosmic rays to serve as an energy source. From this abundant source of high energy particles, alpha particles are filtered out for carrying out a nuclear transmutation reaction of Nitrogen-14 for the production of a high calorific fuel - Hydrogen, and Oxygen-17. This fuel can be used in fuel cells, an efficient device for energy extraction, and the product will be water, but with theOxygen-17isotope. Oxygen-17is a stable isotope and hence this water can be used by astronauts during space travel.

The whole idea of using the generated waste that would otherwise had contributed to increasing the space junk seems very unrealistic but its possible. We are not only getting our Nitrogen gas molecules, but we are also contributing towards keeping space clean. "Space Junk" has actually become such big of a problem these days that space agencies like NASA have launched programs to do the cleaning, and hence, this method is very favorable in along that line of thought.

Theoretically the idea is very sound but there are some limitations while thinking of actually implementing it practically. But, if the current progress rate continuous, and if we discover ways to increase the output by overcoming there strictions posed by the cross section, then this process would significantly increase in importance. The farthest that the humans have physically traveled is till the moon, during the Apollo 11 mission. Since then, we somehow haven't been able to go further, as far as human "Space Traveling" is concerned. This process might just be the key to overcome the hurdle and venture for the deeper into the universe.

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