Antimatter Farming in Radiation Belts – Concept and Feasibility Research

Concept:

Radiation belts are zones of charged particles including antimatter which is mostly in the form of anti-protons that arise from interactions between cosmic rays and the upper atmosphere. After 2011's PAMELA mission (Payload for Antimatter Matter Exploration and Light-nuclei Astrophysics) which confirmed that radiation belts where capable of containing antiparticles, "antimatter harvesting" has been proposed mostly in the form of electromagnetic grids (Figure 1) or scoops that collect and contain the particles making use of their negative charge. In 2019 CMS (Compact Muon Solenoid) announced that an antimatter collector designed for the Van Allen radiation belt (Figure 2) was under construction however whether this is true or not is not confirmed either way.

Possible use:

While antimatter is possible to synthesise on earth the sheer quantity of energy needed to produce it makes using antimatter annihilation as an energy source unfeasible*. Therefore, the possibility of being able to harvest antimatter without expending (quite so much) energy is very attractive for both large scale power generation and interplanetary space travel (figure 3 and 4).

Evaluation of feasibility:

Now all this is well and good in theory but how much antimatter can we harvest from the Van Allen radiation belts?

It is estimated that a total of 160 nanograms** of antiprotons currently exist in the inner Van Allen radiation belt.

It's unrealistic to expect to harvest all the available antimatter at most we are looking at a harvesting rate of 2 nanograms a year** which equates to an energy output of 179751 joules but considering the timeframe it only comes out to 0.0057 watts which may not even make up for the power requirement for the electromagnetic scoops or grids. It may be much better to harvest the antimatter in orbit or Saturn (240 μg per year**) which has a higher antimatter concentration due to its ring system.

Considering our current technology generating power through antimatter isn't particularly feasible however collecting it through the radiation belts rather than particle accelerators may be more cost effective and so is an idea worth pursuing.

* Each antiproton requires 4.17×10^{-9} Joules of energy to synthesise which isn't a lot but considering an antiproton produces only 1.5×10^{-10} it results in an abysmal efficiency of 3.6%

** Source: NASA: https://centauri-dreams.org/wp-content/Bickford_Phase_II.pdf

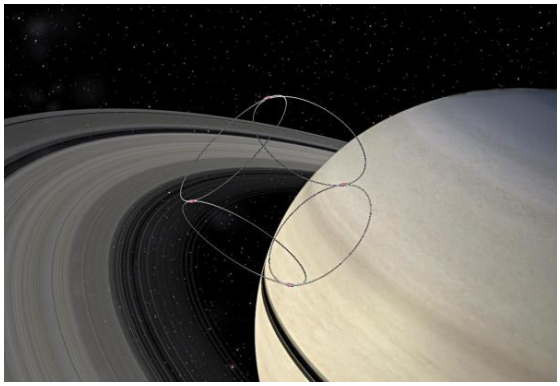

Figure 1: A render of a large antimatter collector in orbit of Saturn (Credit: Steve Bowers)

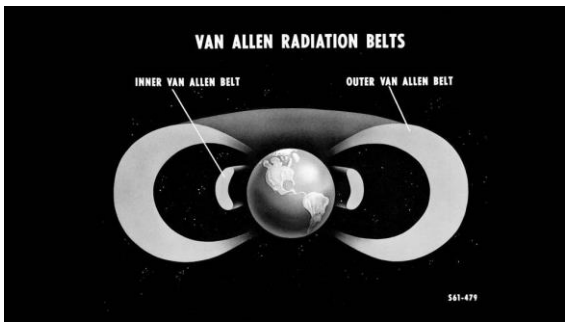

Figure 2: A diagram showing the inner and outer Van Allen radiation belts, the inner one is comprised of mostly protons and the outer electrons (Credit: NASA)

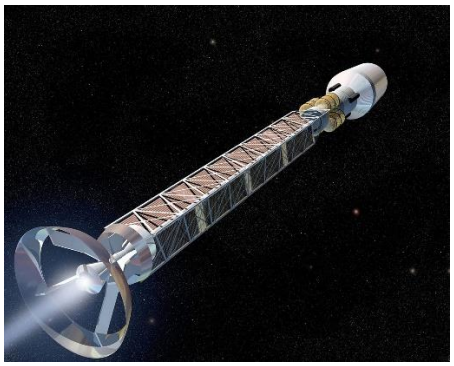

Figure 3: A render of an antimatter thruster, antimatter propulsion has the possibility to be both extremely efficient and with a reasonably high thrust which makes it an attractive choice for interplanetary or interstellar missions (Credit: NASA: https://ntrs.nasa.gov/api/citations/20200001904/downloads/20200001904.pdf)

Figure 4: The ISV Venture Star from Avatar is said to use antimatter propulsion (Credit: James Cameron, 20th Century Fox)