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Near Earth Asteroids - Prospection, Orbit Modification and Mining

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Abstract

The number of known Near Earth Asteroids (NEAs) has increased continuously during the last decades. Now we understand the role of asteroid impacts for the evolution of life on Earth. To ensure that mankind will survive in the long run, we have to face the "asteroid threat" seriously. On one hand we will have to develop methods of detection and deflection for Hazardous Asteroids, on the other hand we can use these methods to modify their orbits and exploit their resources. Rare-earth elements, rare metals like platinum group elements, etc. may be extracted more easily from NEAs than from terrestrial soil, without environmental pollution or political and social problems.

In a first step NEAs, which are expected to contain resources like nickel-iron, platinum group metals or rare-earth elements, will be prospected by robotic probes. Then a number of asteroids with a minimum bulk density of 2 g/cm³ and a diameter of 150 to 500 m will be selected for mining. Given the long duration of an individual mission time of 10-20 years, the authors propose a "pipeline" concept. While the observation of NEAs can be done in parallel, the precursor missions of the the next phase can be launched in short intervals, giving time for technical corrections and upgrades. In this way a continuous data flow is established and there are no idle times.

For our purpose Potentially Hazardous Asteroids (PHAs) seem to be a favorable choice for the following reasons: They have frequent close-encounters to Earth, their minimum orbit intersection distance is less than 0.05 AU (Astronomic Units) and they have diameters exceeding 150 meters. The necessary velocity change (delta V) for a spaceship is below 12 km/s to reach the PHA.

The authors propose to modify the orbits of the chosen PHAs by orbital maneuvers from solar orbits to stable Earth orbits beyond the Moon. To change the orbits of these celestial bodies it is necessary to develop advanced propulsion systems. They must be able to deliver high thrust and specific impulse to move the huge masses of the asteroids.

Such a propulsion system could be the Bussard Fusion System, also known as the quiet-electric-discharge (QED) engine. It uses electrostatic fusion devices to generate electrical power. The fuel consists of Deuterium and Helium3 that are fusing to Helium4 plus protons releasing 18.3 MeV of energy per reaction. The charged protons escape from the confinement; their kinetic energy can be converted to electricity or be used directly as a plasma beam for generating thrust. For the reaction a specific energy of 3.5×10^{14} Joule/kg can be computed, i.e. orders-of-magnitude higher than for any existing propulsion system.

As an example we take the Asteroid with the designation 2008 EV5. It is classified as an Aten group asteroid with a mean diameter of 450 meters and belongs to spectral type S (stony asteroids). Our mass estimate (using a bulk density of 3 g/cm³) is 1.4×10^{11} kg. To transfer 2008 EV5 to an Earth-like orbit the energy required is estimated to be in the order of 2.8×10^{18} Joule. This is the difference in Kepler energy between the NEA´s current orbit and the Earth´s orbit around the sun. Using the Bussard Fusion System the amount of fuel would be approx. 8000 kg of Helium3.

To move an asteroid by remote control the authors propose to design *unmanned space tugs* which are propelled by Bussard Fusion Engines. A pair of space tugs is docked to each asteroid using drilling anchors. The fusion engines of the tugs then apply the thrust forces for the maneuvers. The first tug, which carries the main fuel quantity, applies the primary force for the orbital maneuvers. The second one adjust the flight track by short engine thrusts.

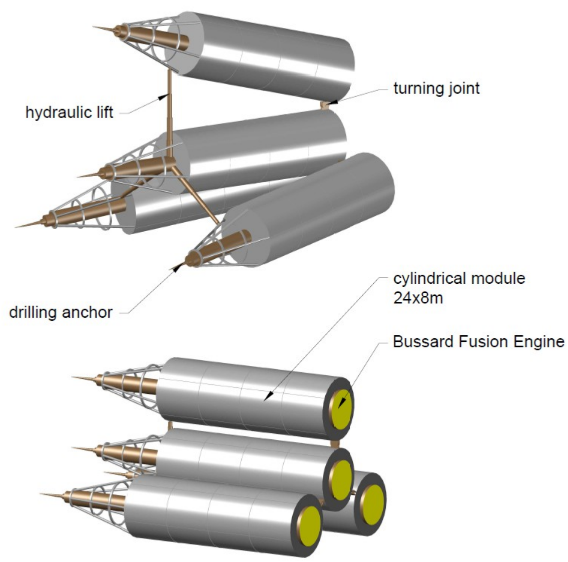

Figure 1: Asteroid Space Tugs

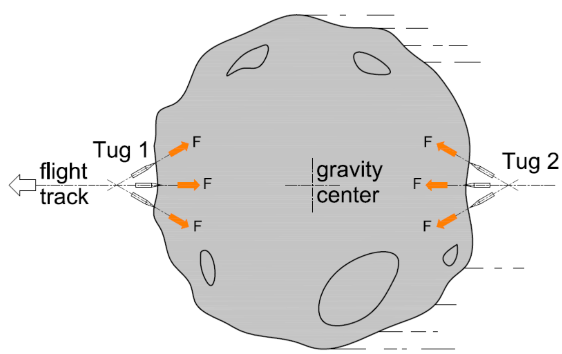

Figure 2: Asteroid, guided by space tugs

Once stabilized in an Earth orbit beyond the Moon, the mining process can be started along the major axis of the asteroid. A *manned space station* can be connected to the asteroid, carrying digging, conveying and processing machinery and storage modules. The *Active Mining Head* initially digs a main central tunnel of 8 m in diameter to the center of the asteroid, where the heavy elements are supposed to be. Then it excavates a spherical or cylindrical cave up to 50% of the NEA´s volume. While the mass of the asteroid decreases constantly, its orbit is stabilized by the two space tugs. The excavated cavern is permanently filled with a pressurized gas. Thus the muck (the rock chips) can be removed easily in a flexible vacuum conveyor tube. In the manned mining station the raw material is processed, stored and prepared for transport. Finally it is transported by *unmanned cargo ships* to Low Earth Orbit or to the Lagrange Points of the Earth-Moon system for further industrial use, e.g. in metallurgical plants.

An Earth orbit beyond the Moon instead of the NEA´s original Solar orbit will be advantageous for the mining process: the rate of mining advance, muck removal and storage can be kept equal to the rate of cargo shipping. After the end of the mining process a hollow celestial body will remain. The thickness of the stony crust depends on the bulk density and the diameter of the asteroid and the cave. It should be at least 30 to 50 m. The inner surface of the cave and the tunnel can be lined by laser sintering to create a smooth walling.

The former hazardous asteroid has now become a small artificial moon of Earth in a stable orbit. The cave can be used as a shelter for industrial facility or the storage of products like water, oxygen or other gases for an increasing industry in space. Oxygen, Hydrogen and Carbon can be extracted from C-Type and similar asteroids, which will be “captured “ later using the above mentioned technologies.

Last not least NEAs with more than 400 m in diameter can be used for *rotating human colonies* with artificial gravity. The remaining crust of the celestial body provides shelter against cosmic rays, solar flares and micrometeorites.

To use asteroid resources will be a crucial step of human evolution, it will definitely establish human civilization in space. To be independent from planet Earth is a “life insurance” for the human species in case of global disasters caused by nature itself, like super vulcanoes, ice ages, novae and other cataclysmic events that we may expect from tomorrow to the far future.

Reference

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