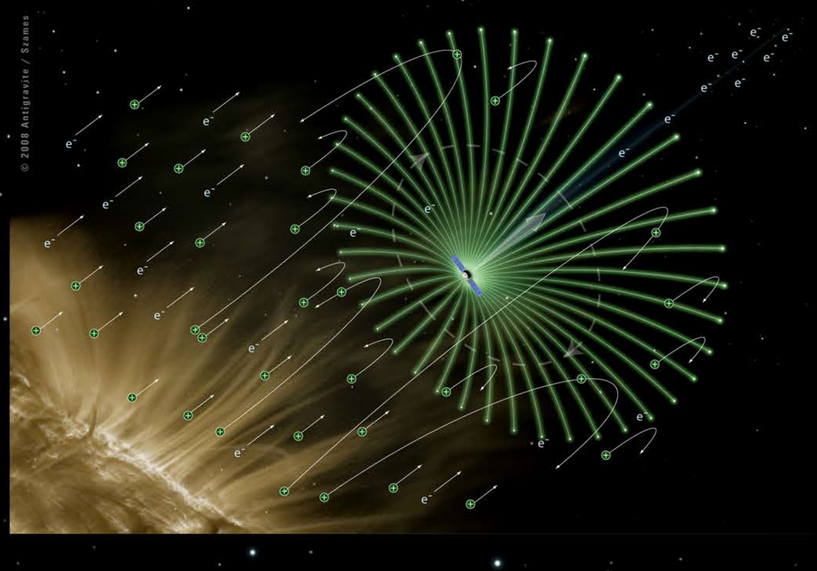
NANOSATELLITE TECHNOLOGY FOR SOLAR SYSTEM EXPLORATION

Nanosatellites

Nanosatellites are defined as having a mass between 1 and 10 kg. They have become increasingly more popular since the end of previous century because of the miniaturization of technology and the development of the CubeSat standard. During this period more than 400 nanosatellites have been launched [1]. Nanosatellites have grown from simple and mostly educational satellites to platforms for technology demonstration, Earth observation and scientific experiments. Nanosatellites are a cost-effective approach to space exploration, which enables missions with shorter development cycles and higher risk factors. In recent years, more and more ideas of using nanosatellites for interplanetary missions are being discussed and developed.

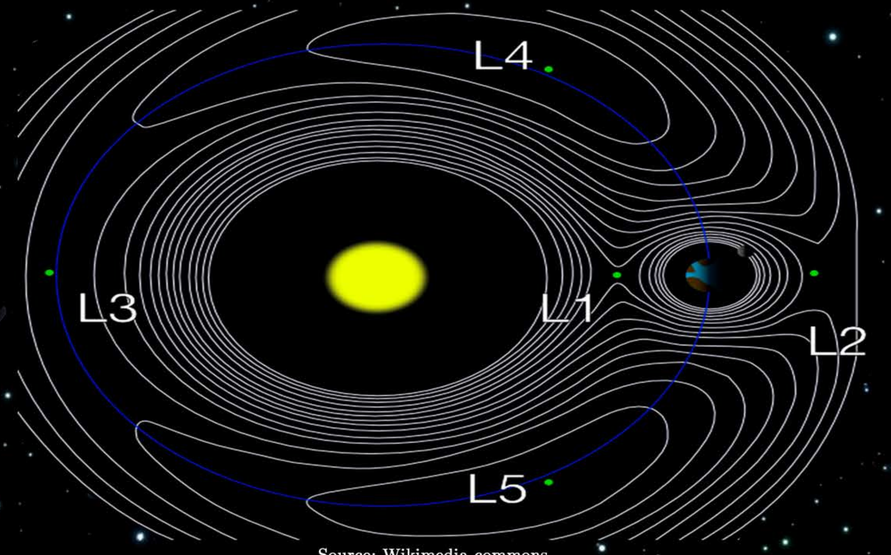


Electric solar wind sail (E-sail)

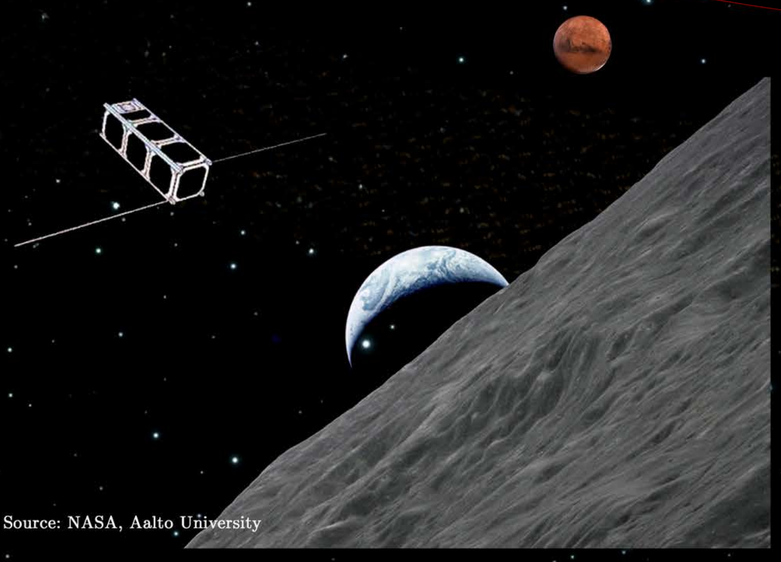
The E-sail is a novel propulsion technology that uses the natural solar wind for producing spacecraft thrust. It consists of long, thin, conducting, and centrifugally stretched tethers that are positively charged [2,3]. The E-sail is a promising propulsion system concept because it provides a high and continuous thrust with its large effective sail area and small mass. The E-sail has the potential to decrease the cost of interplanetary travel and, at the same time, it allows for faster travel speeds and enables new missions [4]. In low Earth orbit, E-sail spin-off technology, plasma brake, can be used for deorbiting satellites [5]. The E-sail can be used on satellites as small as three-unit CubeSats and it can be used on a mothership for transporting nanosatellites in the Solar System.

Off-Lagrange point solar wind monitoring spacecraft

One of the first, simplest and most cost-effective applications of the E-sail could be a nanosatellite placed between the L1 Lagrange point and the Sun. The thrust required to keep the satellite in such a position would be provided by a single 1 km long tether, a high voltage source and an electron gun. One of the best applications for such a satellite is space weather prediction with extended warning time. The satellite would be equipped with a magnetometer on a boom. In addition, plasma density can be determined by measuring the electron current flowing in the tether and the solar wind speed can be determined by measuring the E-sail thrust.



Source: Wikimedia commons



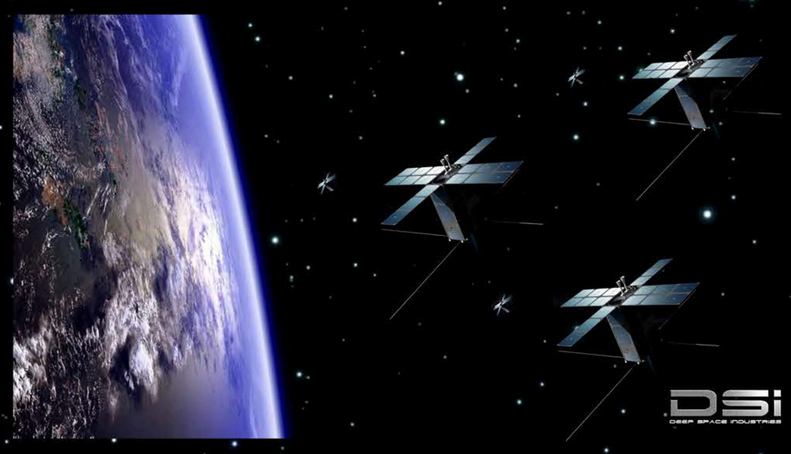
Source: NASA, Aalto University

Earth monitoring satellite in Moon orbit

One instrument per satellite - is the approach for science missions that is increasingly benefitting from the use of nanosatellites. With increasing level of technological maturity and wide range of launch options, nanosatellites can help to cover a wide scope of science possibilities that would otherwise be considered as science 'niche' or non-essential complementary measurements. It would, for example, be possible to measure the spectral albedo of the Earth on planetary scale. A wide spectrum and optimally high spectral resolution measurement of the whole Earth albedo signal complements existing LEO, GEO and L1 Earth monitoring satellite measurements and help further improve global scale models of various atmospheric processes. Similar mission approach has also been used successfully in the BRITE nanosatellite constellation that observes bright stars [6]. Bright star variability observations is a science 'niche' that ground-based telescopes are not effective to observe and neither most space telescopes, as their focus is on faint stars.

Asteroid exploration and mining with nanosatellites

Asteroid mining has become a popular topic in the media and for the future of space exploration. Asteroid prospecting is necessary for its scientific value and providing materials for the innovative approach of building spacecraft and satellites in space. Nanosatellites also have a part to play in making asteroid mining a possibility as a platform for testing technologies and prospecting of asteroids as part of larger missions. Using nanosatellites to survey asteroids as part of an asteroid mining mission is an idea proposed by different teams also including Deep Space Industries and Cranfield University [7]. CubeSats could also be used to analyse the contents of a lot of asteroids for research purposes by placing satellites on Earth-Moon Lagrange point, which is a cheaper and faster alternative to other approaches [8].



Nanosatellite swarms

Swarms of nanosatellites have many applications in exploring various objects in the Solar System. A nanoSWARM mission in Moon orbit has been proposed to address mechanisms of space weather, origins of planetary magnetism, origins and distribution of water on airless bodies, physics of small scale magnetospheres [9]. Groups of nanosatellites deployed in the vicinity of a planetary body could make gravity estimates by measuring changes in the velocity and position of nanosatellites relative to one another [10]. They could also be used for mapping surfaces of various celestial bodies. By using nanosatellites as receivers of pulses generated by the mothership, they could allow for mapping the internal structure of asteroids. Nanosatellites like ExoplanetSat (now ASTERIA) and bigger can be used as space telescopes to characterise exoplanets or other celestial bodies.

References:
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