EGU23-14692
EGU General Assembly 2023

Project DragLiner: Harnessing plasma Coulomb drag for satellite deorbiting to keep orbits clean

Maria Genzer[1], Pekka Janhunen[1], Harri Haukka[1], Antti Kestilä[1], Maria Hieta[1], Pyry Peitso[2], Perttu Yli-Opas[2], Hannah Ploskonka[2], Janne Sievinen[2], Marco Marques[3], David Macieira[3], Ahmed El Moumen[3], Farzaneh Gholami[3], Miguel Olivares-Mendez[4], Baris Can Yalcin[4], and Carol Martinez Luna[4]

[1]Finnish Meteorological Institute, Space research and observation technologies, Helsinki, Finland (maria.genzer@fmi.fi)
[2]Aurora Propulsion Technology, Espoo, Finland (pyry.peitso@aurorapt.fi)
[3]Gradel sarl, Eliange, Luxembourg (m.marques@gradel.lu)
[4]SpaceR-SnT/University of Luxembourg, Luxembourg Kirchberg (bariscan.yalcin@uni.lu)

When a high-voltage charged tether is put into streaming space plasma, the tether's electric field disturbs the flow of plasma ions and thereby taps momentum from the plasma flow [1-4]. The effect is called electrostatic Coulomb drag. One application is the electric solar wind sail which uses the solar wind to generate interplanetary propulsion [1, 2]. Another application is the Plasma Brake [3, 4] which uses the ionospheric ram flow to generate Coulomb drag that slowly de-orbits the satellite. Both positive and negative tether polarities work. The plasma physics is different, but the net effect is a transfer of momentum in both cases. The reasons are somewhat complicated, but there is good motivation to select positive polarity in the solar wind case and negative polarity in the ionospheric Plasma Brake case. Measurement of Coulomb drag in Low Earth Orbit and testing deployment of tether is to be carried out by ESTCube-2 cubesat [5] which is scheduled for launch in spring 2023, and forthcoming Foresail cubesat scheduled for launch later in 2023-2024.

Project DragLiner is ongoing and funded by ESA to define requirements and a preliminary design of a passive Coulomb Drag based deorbit system capable of bringing down LEO spacecrafts in an order of magnitude shorter time than the current regulations of re-enter time for the spacecraft (25 years). Other main requirements for the deorbiting system are low mass and independence from the spacecraft resources. The project will also create a TRL 4 prototype of a Plasma Brake module that can be used to deorbit a few hundred kilogram satellite or launcher upper stage from Low Earth Orbit. The module deploys ~5 km long tether that is made of four 25-50 micrometre diameter conductive wires. In addition to aluminium wires used previously in Cubesat projects we will also evaluate more advanced carbon fibre composite wires. The redundant multi-wire tether structure is used so that the tether does not break even when micrometeoroids cut some of its wires. The tether is deployed from a storage reel. The tether is kept at -1 kV voltage by an onboard high-voltage source. A ~100 m long metal-coated tape tether is used as an electron-gathering surface that closes the current loop. Alternatively, conducting parts of the debris satellite could be used for electron gathering. The power consumption is a few watts.

Project Dragliner uses basic Space Plasma Physics to solve a practical and important problem of keeping satellite orbits clean for future generations and preventing a catastrophic Kessler syndrome scenario.

[1] Janhunen, P., Electric sail for spacecraft propulsion, J. Prop. Power, 20, 763-764, 2004.

[2] Janhunen, P. and A. Sandroos, Simulation study of solar wind push on a charged wire: basis of solar wind electric sail propulsion, Ann. Geophys., 25, 755-767, 2007.

[3] Janhunen, P., Electrostatic plasma brake for deorbiting a satellite, J. Prop. Power, 26, 370-372, 2010.

[4] Janhunen, P., Simulation study of the plasma-brake effect, Ann. Geophys., 32, 1207-1216, 2014.

[5] Iakubivskyi, I., et al., Coulomb drag propulsion experiment of ESTCube-2 and FORESAIL-1, Acta Astronautica, 177, 771-783, 2020.