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TETHERS AND ORBIT PROPAGATION

**Abstract**

A bare electrodynamic tether (EDT) is a conductive thin wire or tape up to several kilometers long, which is kept taut in space by gravity gradients or by spinning, and is left bare of insulation allowing it to collect (and carry) current as a cylindrical Langmuir probe in an ambient magnetized plasma. Two main elements are essential for EDT's: magnetic field and plasma density. In environments where these are present conductive tethers can provide both power and propulsion, and this makes them especially attractive for planetary exploration. Whereas the use of electrodynamic tethers is readily possible for Jupiter, the case for the other three Outer Giant Planets, Saturn, Uranus and Neptune, presents issues because their magnetic fields are much weaker.

From the orbital point of view, capture is the most essential issue for a tether mission to Saturn or the Ice Giants, because there will be only one opportunity for success. Once the tethered spacecraft is captured by the gravity of the planet, a space tether could carry a spacecraft through the neighborhood requiring neither propellant nor power supply. The basic scenario for such captures have been described in several papers for the case of Jupiter. Lately, such analysis has also been adapted to Saturn and Neptune.

In the case of Saturn, for example, capture requires the reduction of the relative velocity of the S/C. Tether drag can be used to perform such a reduction, however this is a real challenge due to the smallness of Saturn's magnetic field  $B$ . To enable this requires innovative trajectory design to develop the proper conditions to maximize an EDT's effectiveness.

To help with such developments, an orbital propagator was developed by the SDG-UPM based on a set of redundant variables including Euler parameters, called DROMO1. It is closely related to the concept of ideal frame introduced by Hansen in the XIX century. In addition to offering numerical solutions with remarkable speed and precision, the theory on which DROMO rests allows obtaining analytical and semi-analytical solutions of some interest.