1. **Title of the presentation**

Study of magnetospheric propulsion (eMPii)

2. **Speaker**

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3. **Abstract**

Magnetospheric propulsion has been proposed as a revolutionary propulsion concept that could provide spacecraft with unprecedented speeds of 50 to 80 km/s or 10 AU/year for low power requirements. Such speeds could enable spacecraft to travel out of the solar system within a 10-year mission. It has been speculated that this could be achieved by harnessing the solar wind dynamical pressure to thrust the spacecraft. Coupling to the solar wind would be produced through an artificial magnetosphere generated around the spacecraft either by utilizing a large-scale vacuum magnetic field using a large superconductive coil or by injecting plasma into a magnetic field supported by solenoid coils on the spacecraft. Larger spatial scales than in traditional solar sails are required, as the dynamical pressure of the solar wind is much weaker than the radiation pressure of the Sun.

We have addressed in this study both the plasma-free (PFMP) and plasma-inflated (M2P2) magnetospheric propulsion concepts. Deriving the scaling laws of the key parameters of both concepts we have shown that the plasma-free concept is theoretically sound. In the plasma-inflated manetosphere the injected plasma, however, introduces a third massive body in the system that could introduce an additional sink for the solar wind momentum. The injected plasma could leak out from the magnetosphere and carry away a major fraction of the solar wind momentum. Our analysis indicates that the force exerted by the magnetopause current on the spacecraft is much weaker than the force exerted by the solar wind on the magnetopause. However, a possible way of efficient transmission of the force acting on the magnetopause to the spacecraft would be that a current system is established very close to the spacecraft.

We have studied the relevant parameter ranges and requirements for computer simulations of both PFMP and M2P2 concepts. The parameters were studied for a full-scale mission, and space-based and ground-based demonstrations of the propulsion concepts. Three methods of generating the magnetic field were studied: superconducting coil, ohmic coil, and a permanent magnet. The estimates for the computer memory and computing time requirements were obtained for MHD, hybrid, and full-particle simulations of the M2P2 concept.

The parameter ranges of the propulsion concepts are promising for aspace-based demonstration: A force acting on the magnetopause adequate for measurable levels of acceleration can be generated. However, the major issue in the case of M2P2 is the

transfer of the magnetopause force to the spacecraft. The required current closure near the spacecraft implies that the plasma density has to be quite large. The existence of such a current system is presently an open question and can only be addressed by space-based or ground-based demonstrations or, perhaps, by computer simulations. A pre-existing MHD simulation code used for planetary magnetospheres can be optimized for the parameter ranges of the magnetospheric propulsion concept with a reasonable effort. In the case of hybrid simulation, the large magnetic field magnitudes may lead to considerable difficulties in adapting pre-existing hybrid codes to the issue of magnetospheric propulsion.

A demonstration mission is suggested to consist of a pair of spacecraft to be flown in the solar wind. One of the spacecraft is the primary spacecraft carrying the instruments to create the artificial magnetosphere. The second spacecraft is equipped to monitor the solar wind conditions, measure the acceleration of the spacecraft, and occasionally fly through the artificial magnetosphere to monitor its structure and plasma parameters. Both propulsion concepts can be addressed during a single mission.