

LORENTZ-ACTUATED ORBITS: ELECTRODYNAMIC PROPULSION WITHOUT A TETHER

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A charged particle moving relative to a magnetic field accelerates in a direction perpendicular to its velocity and the magnetic field due to the Lorentz force. This effect can be seen, for example, in the unusual celestial mechanics of dust particles in the rings of Jupiter. This study evaluates the use of the Lorentz force as a revolutionary means of accelerating a spacecraft. As the spacecraft orbits a planet, the co-rotational electrical field (associated with the rotating planetary magnetic field) does mechanical work, increasing or decreasing the orbit's semimajor axis. The implications are remarkable: without propellant, a spacecraft can achieve earth escape, drag compensation, and new stable satellite formations. This means of propulsion allows freight and passengers to be transported throughout the solar system, using planetary magnetic fields as stepping stones. Power is required—we do not claim to get something for nothing—but only enough to establish and maintain a high electrical potential on part of the spacecraft. Let us be clear about what the Lorentz-Actuated Orbit (LAO) is not. An LAO does not involve the use of electrodynamic tethers, although the physics is related. By contrast, an LAO-capable spacecraft may be very compact. The charge it carries travels at perhaps thousands of meters per second relative to the geomagnetic field (much faster than the electrons in a tether). This moving charge results in a force similar to what a tether experiences, but the LAO spacecraft offers a far more mass-efficient design. Also, an LAO does not work through electrostatic levitation. That is, an LAO does not take advantage of Coulomb forces that act on the charged spacecraft. Planetary exploration spacecraft (such as JIMO) can use this effect for braking and orbit insertion. Spacecraft bound for distant destinations can use this effect to increase orbital energy through fly-by maneuvers. This study will explore the validity of this concept for spacecraft propulsion within the larger context of NASA's robotic and human missions in the next several decades. Our preliminary investigations suggest that existing technologies can be used to realize modest, though meaningful, ΔV . For transportation of bulk materials and passengers throughout the solar system, the technology for high-capacitance spacecraft must move beyond what is available today.