Electric Sail Propulsion for Exploring Nearby Interstellar Space

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An Electric Sail is a revolutionary propellant-less propulsion system that is ideal for deep space missions to the outer planets, the Heliopause, and beyond. It is revolutionary in that it uses momentum exchange with the hypersonic solar wind to propel a spacecraft within the heliosphere. The momentum exchange is affected by the deflection of charged solar wind particles by an array of electrically biased wires that extend outward up to 30 km from a slowly rotating spacecraft. A high-voltage, positive bias on the wires, which are oriented normal to the solar wind flow, deflects the streaming protons, resulting in a reaction force on the wires that is also directed radially away from the sun. Over a period of months, this small force can accelerate the spacecraft to enormous speeds—on the order of 100-150 km/s (~ 20 to 30 AU/yr). Unlike solar sails, Electric Sails do not rely on a fixed area to produce thrust. In fact, as they move away from the Sun and solar wind pressure decreases, the area for solar proton momentum transfer becomes larger, increasing system efficiency. As a result, thrust decreases at ≈1/r**(7/6) instead of the ≈1/r**2 rate typical for solar sails. The net effect is that an increased radial range of operation, together with increased thrust, both contribute to higher velocities and shorter total trip times to distant destinations. The MSFC Advanced Concepts Office (ACO) was awarded a Phase II NASA Innovative Advanced Concepts (NIAC) study to mature the technology for possible future demonstration and implementation. Preliminary results indicate that the physics of the system is viable and that a spacecraft propelled by an Electric Sail could reach the Heliopause in less than 15 years — and could be developed within a decade.