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Strategies for Rapid Implementation of Interstellar Missions: Precursors and Beyond (4)

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LASER LIGHTSAIL SPACECRAFT FOR INTERSTELLAR EXPLORATION

Abstract

A grand challenge for photonics is the use of laser light as a fuel for space exploration. This is the challenge of designing light-propelled spacecraft capable of reaching the stars beyond our solar system, since light itself is the only fuel capable of propelling spacecraft to the relativistic speeds needed to achieve interstellar travel. We are exploring the role of nanophotonic principles to design self-guiding optical propulsion of subwavelength thickness but macroscopic area laser-driven lightsails via radiation pressure. The challenge is to define materials characteristics required to realize robust, thermally stable building blocks, and find that stable trajectories for dynamic motion of macro-objects can be achieved by controlling the anisotropy of light scattering along the object surface. Nanoscale control of scattering across a large area creates restoring behavior by engineering the scattered phase, without needing to focus the incident light beam or excessively constrain the shape, size or material composition of the lightsail. Our findings give conceptual guidance for stable manipulation of macroscopic objects by radiation pressure. Recently, the Breakthough Starshot initiative has captured scientific imagination and motivated thinking about conceptual prototypes for light-driven spacecraft that could reach nearby stars within a human lifetime. I will describe how this audacious concept may be closer than we imagine, if advances in materials and nanophotonics can enable key concepts for spacecraft propulsion and instrumentation.