

Solar Sail Propulsion: A Roadmap from Today's Technology to Interstellar Sailships

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Abstract

Solar sail propulsion systems are maturing rapidly and will soon enable science and exploration missions that are simply impossible to accomplish by any other means. Solar sail technology is rapidly advancing to support these demonstrations and missions, and in the process, is incrementally advancing one of the few approaches allowed by physics that may one day take humanity to the stars. Continuous solar pressure provides solar sails with propellantless thrust, potentially enabling them to propel a spacecraft to tremendous speeds— theoretically much faster than any present-day propulsion system. The next generation of sails will enable us to take our first real steps beyond the edge of the solar system, sending spacecraft out to distances of 1000 Astronomical Units, or more. In the farther term, the descendants of these first and second generation sails will augment their thrust by using high power lasers and enable travel to nearby stellar systems with flight times less than 100 years – a tremendous improvement over what is possible with conventional propulsion systems. By fielding these first solar sail systems we are actually developing a capability to reach the stars.

Maturing these systems from today's state-of-the-art as exemplified by The Planetary Society's LightSail [1], the Japanese Aerospace Exploration Agency's IKAROS [2], NASA's Near Earth Asteroid Scout [3], and the proposed Earth-to-Orbit Beamed Energy eXperiment (EBEX) [4] will not be quick or easy and the development paths for solar photon sails and beamed energy sails will quickly diverge. Each order of magnitude improvement in sail size (for solar photon sails) and performance (for both) will require advances in materials science; spacecraft attitude dynamics and control during deployment and flight; flight guidance, navigation and control; and, eventually, in-space sail fabrication capability.

A notional solar and beamed energy sail technology maturation plan (with performance metrics) will be outlined. A discussion of the real-world engineering challenges facing today's first generation missions and the design and development challenges for those in the next generation will be described. Finally, a step-by-step approach for developing sails of increasing capability and performance will be proposed – leading to the sailcraft required for true interstellar travel.

Keywords: Solar Sail, Beamed Energy Sail

References:

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