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EXPLORATION OF THE HELIOPAUSE USING LIGHT-SAILS

Abstract

In April 2016, Stephen Hawking and Yuri Milner launched Project Starshot: a mission to send a laser-powered light sail to Alpha Centauri within a generation . This project is surely one of the most ambitious endeavours ever attempted – but requires significant technological development and verification before a launch becomes feasible.

To this end, the Starshot team have solicited from the community suggestions for potential testing goals, to test the spacecraft's systems before the interstellar voyage itself is attempted. In this paper, we argue that exploration of the magnetic boundary of the outer Solar System (the heliopause) is an ideal target, and would yield significant scientific discovery in addition to enabling spacecraft proving.

At the heliopause, the Sun's influence wanes and that of the interstellar medium takes over. Thus far only the Voyager spacecraft have crossed it, returning important results but with very limited spatial coverage and badly degraded instruments as a result of their forty-year travel.

Many questions remain : how diffuse is the boundary? What shape is it? Does the bow shock exist? The magnetohydrodynamic phenomena which occur at it vary rapidly in time, and have complex three dimensional structures which cannot be comprehensively sampled by single spacecraft.

However, Starshot spacecraft will be launchable en-masse, enabling large-scale exploration of regions of interest. Assuming a prototype is capable of travelling at 1

Furthermore, we show that with minimal modification current commercially available technology can be adapted to measure heliopause magnetic fields. These are significant drivers of MHD phenomena, but cannot be remotely sensed accurately and hence are very poorly constrained. Similarly, use of radio-frequency instrumentation mission may enable groundbreaking in-situ measurements of the outer Solar System plasma properties.

Target trajectories and geometries are devised to enable optimum coverage of the boundary, enabling sampling of numerous fundamental phenomena and regions of parameter space not accessible in the laboratory or in near-Earth environments.

Demonstration of the techniques described here would show the suitability of such instrumentation for inclusion on future Starshot missions to Alpha Centauri; where they could investigate key features of both the stellar and planetary systems even from distant flybys.