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

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DECELERATING INTERSTELLAR PROBES WITH MAGNETIC SAILS

Abstract

As hard as it is to accelerate an interstellar craft, it is even more difficult to decelerate the probe at destination. With energy and mass requirements ruling out active deceleration techniques, the only option remaining is to transfer momentum to either the photons of the target star or to the interstellar medium. In the latter scenario a superconducting loop carrying currents of the order of 0.01-1.0 million ampere creates a magnetic field that reflects interstellar protons.

The density of the interstellar medium is very low, ranging from 0.05-0.20 protons per cubic-cm for the local clouds to about 0.005 per cubic-cm for the local bubble. Decelerating an interstellar craft needs hence both a very large effective reflection area and extended time spans. Our simulations show that a craft cruising at about 1000 km/s (1/3 percent of the velocity of light) may be decelerated by a magnetic sail with a radius of about 50 km. The mass requirements for the sail, about 1.5 tons, are comparably modest, implying that the mission parameters would lie well within the specifications of the directed energy launch system envisioned by the Breakthrough Starshot initiative. We find furthermore that the required mass increases rapidly with cruising velocity, making magnetic braking techniques unfeasible for faster interstellar crafts.

An interstellar craft cruising at 1000 km/s, while being about 50 times faster than the Voyager probes, would still take more than thousand years to reach the nearest stars. Magnetic sail techniques are therefore only viable if time is not a critical mission parameter. Missions able to decelerate would hence be suitable only for delivery, but not for primary exploration. Prospective payloads could be self-replicating robots, as a possible venue to build a deep space base, or germs of terrestrial microbes for the seeding of potentially habitable but otherwise lifeless exoplanets. Our results indicate in any case that magnetic sails are a suitable tool for the passive deceleration of interstellar crafts.