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

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THE PATH TO INTERSTELLAR FLIGHT

Abstract

Achieving relativistic flight and enabling the first interstellar missions would be a watershed moment in human evolution. To do so requires a complete change in our propulsion capabilities with a radical leap in technology. The path we have proposed and are currently developing involves the use of very large scale power projection using photonic directed energy. We have shown in a series of 60 technical papers and multiple laboratory demonstrations since our program started in 2009 that while this is extremely difficult, it appears nonetheless to be possible. The key to the success of this program lies both within the exponential growth of photonics as well as in the understanding of a massively parallel system topology. This is unlike any existing propulsion technology in that it is extensively scalable, with no upper limit to power using a nested MOPA (Master Oscillator Power Amplifier) beacon-locked topology. Additionally, this modular and scalable approach to power projection allows for a cost-effective roadmap to the long-term goal of relativistic flight, and includes an extremely large application space prior to that goal being reached. Like any transformational technological progression, there are a large number of critical milestones to be overcome. We have proven in laboratory prototypes that some of the critical milestones have already been realized, including showing that we can phase lock on baselines of >50km, far in excess of what is needed for the first relativistic missions. We have also shown we can build the critical photonics amplification with a wall-plug efficiency of ∼45% and a coherence length of >30km. We have also shown that we can simultaneously amplify in a bidirectional fashion with a dynamic range of $>10^{11}$. A critical element of this program is that along its path comes the opportunity to vastly change our capabilities in other areas using the same core technology. Among these is the ability to project power over vast distances, enabling rapid exploration of our solar system with robotic and crewed missions using both a Direct Drive Mode (direct photon momentum transfer for ultra-high-speed, low-mass missions) and an Indirect Drive Mode (photovoltaic conversion on the spacecraft to power high I_{sp} ion and other engines for high-mass solar system missions). There are still many remaining technological and economic obstacles to overcome, but we are currently on a path that could allow the next generation to achieve the goal of humanity's first interstellar mission with robotic probes.