Enabling The First Generation of Interstellar Missions

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Abstract

If we want to reach the nearest stars in flight times that are within a human lifetime we must achieve relativistic flight which means we must radically change the ways in which we both propel spacecraft and the way in which we design them. Conventional propulsion systems used for interplanetary travel will not work for this purpose. Any mass ejection propulsion system including nuclear has to confront the issue of the very large mass ratios needed for relativistic flight. The only other alternative is to discover and develop new physics. In this talk we will discuss the fundamental issues of what does and does not work in currently known physics and technology as well as the many challenges we face. Within the realm of known physics we are led to three options with the assumptions above. First is very high efficiency fusion engines with extremely large mass ratios given the relatively low yield of fusion (<1%). Second is to develop an annihilation engine using large scale antimatter production which faces unknown technological hurdles to minimize the secondary mass required to store and react the materials and third is to use directed energy (DE) with the DE drive system left at "home" or some hybrid of the above. With recent advances in photonics and directed energy systems we can now seriously envision and design a large scale DE system that will allow us to reach the nearby stars and exo-planets. We are currently in a NASA Phase II program that is supporting our effort to explore this option and further the development of the underlying technology. With spacecraft from fully-functional gram-level wafer-scale systems ("wafer sats") capable of speeds greater than ¼ c that could reach the nearest star in 20 years to spacecraft for large missions capable of supporting human life with masses more than 10^5 kg (100 tons) that could reach speeds of greater than 1000 km/s this technology offers a radical change going forward. With this technology spacecraft can be propelled to speeds currently unimaginable with existing propulsion technologies. In addition to larger spacecraft, that travel slower, we focus on "spacecraft on a wafer" that include integrated optical communications, imaging and spectroscopy systems, navigation, photon thrusters, radiation and magnetic field sensors combined with "standoff" directed energy propulsion. Since the propulsion system stays "at home" the costs can be amortized over a very large number of missions. Interplanetary shuttle missions, to Mars for example, could be enabled if a second unit were built at the target planet. In addition, the same photon driver can be used for planetary defense, space debris vaporization and de-orbiting, beaming energy to distant spacecraft, beaming power for high I_{sp} ion engine missions, asteroid mining, sending power back to Earth for high value needs, stand-off composition analysis, long range laser communications, SETI searches, and terra-forming. Such systems would transform and enable many other space applications. In April 2015 NASA Phase I funding started. One year later on April 12, 2016 the Breakthrough Foundation announced that they would support this idea with a 100M$ Research and Development program to explore the fundamental technology. On May 12 NASA announced Phase II funding. On May 23 the FY 2017 congressional appropriations request directs NASA to study the feasibility of an interstellar mission to coincide with the 100th anniversary of the moon landing quoting our NASA funded directed energy program as an option to enable this. We will discuss our "roadmap" and show the latest laboratory data. While this program faces enormous challenges, the rewards for mastering this technology will enable truly radical and transformative capabilities.

For technical information on this program see our website:
http://www.deepspace.ucsb.edu/projects/directed-energy-interstellar-precursors
http://arxiv.org/abs/1604.01356
http://www.deepspace.ucsb.edu/projects/implications-of-directed-energy-for-seti
http://arxiv.org/abs/1604.02108

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