Sailing on Light

Abraham Loeb

"Given ships or sails adapted to the breezes of heaven, there will be those who will not shrink from even that vast expanse."
Johannes Kepler in a letter to Galileo Galilei (1610)

By Abraham Loeb on August 8, 2018

Interstellar distances are vast. It takes light four years and three months to cross the distance to the nearest star, Proxima Centauri, which hosts a habitable planet, Proxima b. If there is a civilization on this planet looking at us through a giant telescope, they are still witnessing the Obama era and have yet to learn that Trump was elected almost two years ago. It would take conventional rockets tens of thousands of years to reach that planet. If we wish the journey to take less than a human lifetime, the spacecraft needs to travel faster than a tenth of the speed of light. With currently feasible technology, that is only possible by leaving the fuel behind and using light to push a sail attached to our payload. This is the ambitious concept behind the Breakthrough Starshot initiative, whose Advisory Board I chair. Starshot aims to launch a miniature probe, or "starchip," weighing at most a few grams, propelled by a laser to a fraction of the speed of light. For the first time in human history, thanks to recent advances in laser technology and the miniaturization of electronics the dream of reaching the stars can be fulfilled.

In a recent Forbes article, Ethan Siegel warned that pushing a spacecraft to a fraction of the speed of light using a powerful laser might be regarded by alien civilizations as

an accidental declaration of war. First, we should realize that the risk from upsetting another civilization is negligible. We have no knowledge of the existence and nature of intelligent beings out there. But putting that aside, the Starshot concept contemplates launching a payload of only a few grams. When moving at a tenth of the speed of light, such a payload would merely carry the energy of a common asteroid, only a few meters in size - of order the height of a person. Such asteroids hit the Earth a few times per year and burn up in the atmosphere (click here for a map of such impacts between 1994-2013, which shows an event rate tens of times higher than that quoted by Siegel). Moreover, a gram-scale starschip would burn up in the atmosphere of a planet much more easily than a tonne-mass asteroid. Its impact on a planet would be no more irritating than the impact of a dust grain on the skin of a grazing cow. The interplanetary medium is full of debris that poses far greater risks to a planet, as the dinosaurs realized when wiped out by the impact of a 10-15 kilometer asteroid (a trillion times more massive than we just considered) some sixty five million years ago.

Second, it is impractical to aim a starchip so that it would hit a planet four light years away. This would require an angular precision of a billionth of a radian and there is no way for us to know the relative positions of the planet and the spacecraft to that precision over the decades long journey. The distance of closest approach envisaged for Starshot is thousands of times larger than the size of a planet - implying a chance impact probability of less than one part in a million.

Siegel also worries about the challenges that face the Starshot project, such as the damage to the probe's surface from the impact of interstellar dust grains or atoms. This is a valid concern. We carefully assessed this risk in a recent scientific paper and concluded that a coating layer with a thickness of merely a few millimeters would be sufficient to protect the Starshot payload from the most likely collisions during its journey to Proxima Centauri. He also notes that there is no deceleration mechanism. This constraint is built into the blueprint of the project, which aims to take photographs during flybys of targets of interest. With the Starshot technology we could send a camera to Pluto within a few days instead of the 9.5 years that it took New Horizons to reach it. We could easily chase `Oumuamua, the first interstellar asteroid, which was discovered in the solar system last year, even though conventional rockets cannot catch up with it at all.

When envisioning Starshot in 2016, we studied carefully the characteristics of the launch system required for flyby encounters with targets of interest and concluded that physics imposes no "showstopper" to make the project unfeasible. Our team of distinguished scientists collaborated with the visionary funder of the project, Yuri Milner, in listing more than two dozen technological challenges that it needs to resolve. These can be found on the Starshot project website, and include stable sail design and communication. We aim to dedicate the next decade to a feasibility demonstration of the required laser and sail technologies, and have just started to engage experimental groups in related research. Without any doubt, the project is challenging, but if successful - it will move on to the construction of a prototype system and eventually to the construction of the full system.

Space is the next frontier of our civilization. Starshot potentially represents the next giant leap forward after the Apollo mission - to fulfil humanity's dream of reaching the stars. I have no fear that our arrival on the interstellar highway will provoke road rage

or speeding fines; on the contrary, my hope is that we could find a lot of traffic there and might even receive the friendly message, “Welcome to the interstellar club”.

ABOUT THE AUTHOR

Abraham Loeb

Abraham (Avi) Loeb is chair of the astronomy department at Harvard University, founding director of Harvard's Black Hole Initiative and director of the Institute for Theory and Computation at the Harvard-Smithsonian Center for Astrophysics. He chairs the Board on Physics and Astronomy of the National Academies and also serves as chair of the advisory board for the Breakthrough Starshot project.

Credit: Nick Higgins