First test of Breakthrough Starshot interstellar probe highlights likely damage due to gas and dust

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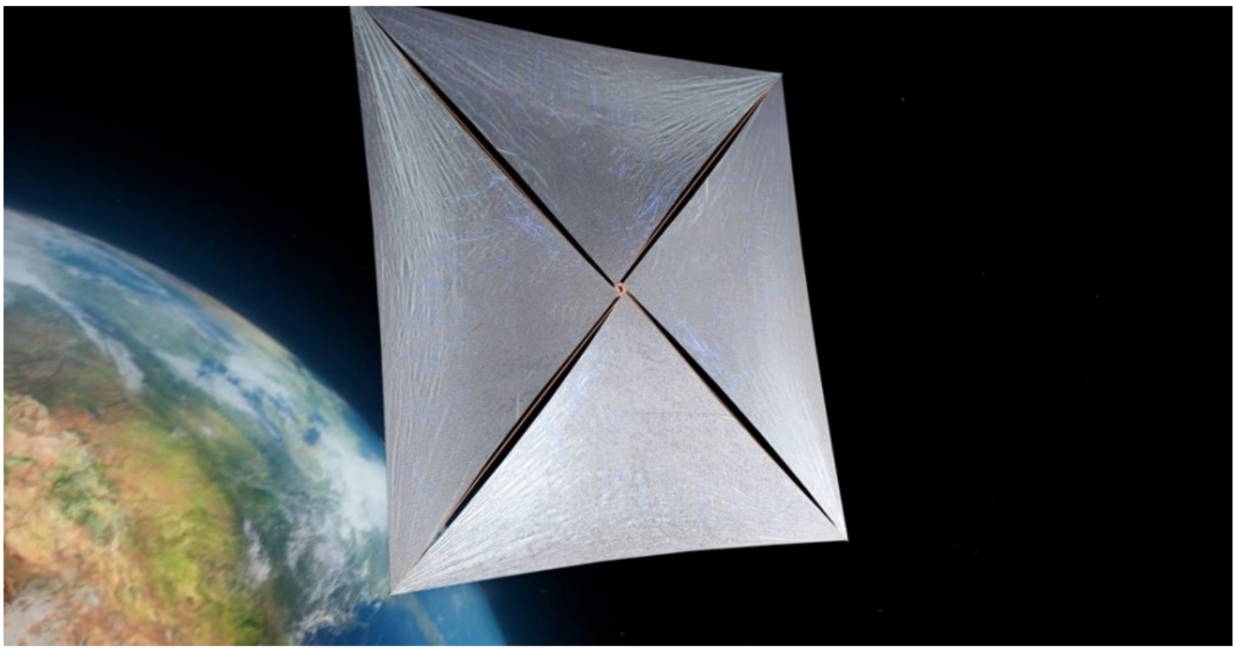

(Phys.org)—A small team of researchers at Harvard University who are part of the Breakthrough Starshot team has been testing the likely damage to an interstellar spacecraft traveling at approximately one-fifth the speed of light as it makes its way to the Alpha Centauri star system. As they note in a paper describing their testing and results, which was uploaded to the *arXiv* preprint server, such damage could be catastrophic, but they believe they have a solution.

Earlier this year, Russian billionaire Yuri Milner announced to the world that he wants to send a probe to the Alpha Centauri star system—he put up $100 million of his own money to get the ball rolling on what is expected to be a multi-billion-dollar effort. At the time of the announcement, Milner told the press that his team of advisors had identified 20 main challenges that would have to be overcome in order for such a mission to be a success. In this new effort, the researchers have addressed one of those challenges—assessing the likely damage to the craft due to space dust and gases, and offering solutions to the problem.

The preliminary working design of a space probe able to travel at ~0.2c is little more than a circuit board that has come to be known as a wafersat—it would be attached to a light sail that would be the target of a laser sent from Earth to push it during the initial part of the journey. The wavsat would be made mostly of graphite and quartz. Thus, the researchers focused the bulk of their testing on these two materials. They discovered that particles of space dust hit by the craft would mostly come in the form of collections of heavy atoms rather than particles—those collisions would cause two problems. The first would be the creation of pits on the surface of the craft, which would result in loss of material (up to 30 percent of the entire craft might be lost).

The second problem is melting. If the craft were unlucky enough to run into something larger, however, the team expects the results would be partial or complete destruction of the craft—but they believe the odds of that happening are small enough to make the project viable. Barring such a collision, the researchers believe that coating the front of the craft with a buffer would be enough to ensure its safe arrival to the Alpha Centauri star system approximately 20 years after launch.

More information: The interaction of relativistic spacecrafts with the interstellar medium, arXiv:1608.05284 [astro-ph.GA] arxiv.org/abs/1608.05284

Abstract

The Breakthrough Starshot initiative aims to launch a gram-scale spacecraft to a speed of v~0.2c, capable of reaching the nearest star system, α Centauri, in about 20 years. However, a critical challenge for the initiative is the damage to the spacecraft by interstellar gas and dust during the journey. In this paper, we quantify the interaction of a relativistic spacecraft with gas and dust in the interstellar medium. For gas bombardment, we find that damage by track formation due to heavy elements is an important effect. We find that gas bombardment can potentially damage the surface of the spacecraft to a depth of ~0.1 mm for quartz material after traversing a gas column of NH~2×1018cm−2 along the path to α Centauri, whereas the effect is much weaker for graphite material. The effect of dust bombardment erodes the spacecraft surface and produces numerous craters due to explosive evaporation of surface atoms. For a spacecraft speed v=0.2c, we find that dust bombardment can erode a surface layer of ~0.5 mm thickness after the spacecraft has swept a column density of NH~3×1017cm−2, assuming the standard gas-to-dust ratio of the interstellar medium. Dust bombardment also damages the spacecraft surface by modifying the material structure through melting. We calculate the equilibrium surface temperature due to collisional heating by gas atoms as well as the temperature profile as a function of depth into the spacecraft. Our quantitative results suggest methods for damage control, and we highlight possibilities for shielding strategies and protection of the spacecraft.