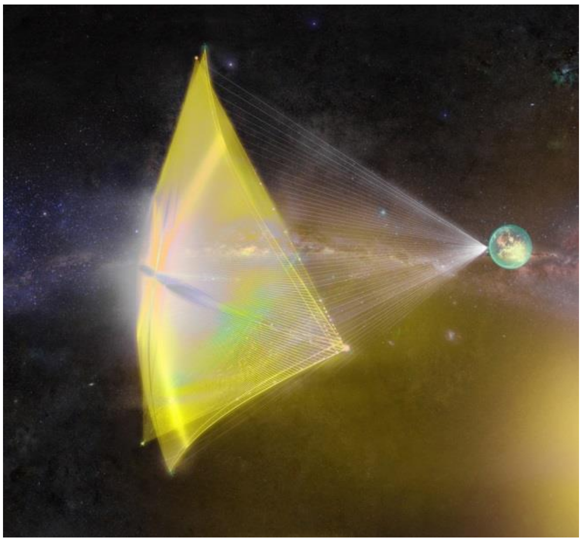
Stephen Hawking's Legacy: Project Starshot

"We can see a path: it begins with that 16 year old boy [Einstein] who dreams of riding a ray of light and flows into our dream we want to realize, traveling to the stars on our own ray of light."(Stephen Hawking).[1]

Breakthrough Starshot is a research and engineering project by the *Breakthrough Initiatives* to develop a proof-of-concept fleet of light sail spacecraft named StarChip, to be capable of making the journey to the Alpha Centauri star system 4.37 light-years away. It was founded in 2016 by Yuri Milner, Stephen Hawking, and Mark Zuckerberg. [2]

The story of humanity is a story of great leaps – out of Africa, across oceans, to the skies and into space. Since Apollo 11's 'moonshot', we have been sending our machines ahead of us – to planets, comets, even interstellar space.

But with current rocket propulsion technology, it would take tens or hundreds of millennia to reach our neighboring star system, Alpha Centauri. The stars, it seems, have set strict bounds on human destiny. Until now.



Light sail, Courtesy of Breakthrough Starshot

In the last decade and a half, rapid technological advances have opened up the possibility of light-powered space travel at a significant fraction of light speed. This involves a ground-based light beamer pushing ultra-light nanocrafts – miniature space probes attached to light sails – to speeds of up to 100 million miles an hour. Such a system would allow a flyby mission to reach Alpha Centauri in just over 20 years from launch, beaming home images of its recently-discovered planet Proxima b, and any other planets that may lie in the system, and there'd be about 4 years for the data to get back to us.

Breakthrough Starshot aims to demonstrate proof of concept for ultra-fast light-driven nanocrafts, and lay the foundations for a first launch to Alpha Centauri within the next generation.

Along the way, the project could generate important supplementary benefits to astronomy, including solar system exploration and detection of Earth-crossing asteroids.

A number of hard engineering challenges remain to be solved before these missions can become a reality. The initiative will also establish a research grant program, and will make available other funding to support relevant scientific and engineering research and development. [3]

In his book "Brief Answers to Big Questions" [1 ff.] Stephen Hawking describes his motivation and the emergence of the project Starshot:

"I teamed up with Juri B Milner to create *Breakthrough Starshot*, a long-term research and development program designed to help make interstellar travel a reality. If we are successful, we will send a probe to Alpha Centauri while the current generation is still alive.

As mentioned, *Breakthrough Starshot* offers humans a realistic possibility of making early trips into outer space, the aim being to probe and evaluate the possibilities of settlement. The mission is to check the feasibility of 3 project goals: miniaturization of space probes, light drive and phase-coupled lasers. The "Star Chip", a fully functional space probe, the size of which is reduced to a few centimeters, is connected to a light sail. The light sail made of metamaterials weighs only a few grams. We are planning 1000 StarChips and light sails to be put into orbit. At the ground an array of lasers at a km-scale will be combined into a single very powerful light beam.

Such a spaceship could not be slowed down, stopped or landed. Still, it would be the moment when human culture becomes interstellar by finally reaching out to the Milky Way. And if *Breakthrough*

Starshot sent us pictures of a habitable planet, it could be of tremendous importance for the future of humanity."

Breakthrough and European Southern Observatories decided in 2017 to work together in the search for habitable planets in the system of Alpha Centauri.

"Let me come back to Albert Einstein. When we find a planet in the Alpha Centauri system, the image of that planet is taken with a camera that moves in a spaceship at one-fifth the speed of light. Due to the effects of the special relativity, the images will be slightly distorted. It would be the first time that a spaceship was traveling fast enough to observe such effects."

According to the Editor's own calculation, the relativity effect for Alpha Centauri would yield, assuming a relative flight speed v_{rel} of 15% of speed of light (c=1.0792512 Billion km/hr, v_{rel} = 0.1619 Billion km/hr), a Lorentz Factor (LF) of 1.011443. [4]
That means an astronaut onboard the *Starshot* flight to Alpha Centaury would age 1.1443% less than his fellow astronauts remaining on Earth, i.e. if the trip takes approximately 20…30 years (one way) he would have gained less than half a year of his lifetime coming back to Earth.
In conclusion, much higher flight speeds would be needed to capitalize significantly on the "anti-aging" effect.

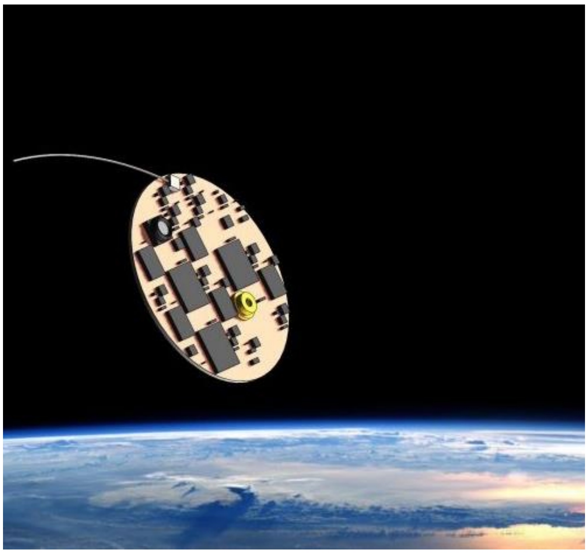
Planning (April 2016) [5 ff]

Pete Worden, Breakthrough Starshot's executive director, and Philip Lubin, a scientific advisor to the project, addressed three of the big questions the project faces.
A major focus of the initial research will be to identify what costs the most in the project and figure out how to drive those costs down.
"We are counting not just on technical increases in capability over time, but radical decreases in price in certain critical areas along the way," Lubin says. The hope is that advances in photonics will improve both the cost and power of laser array technology, just as computers have improved in power and cost over time.

After this basic research is conducted, the project would begin work on a prototype laser array that is tens of meters in diameter, significantly smaller than the final system but big enough to work on all the key challenges the final system would face when it comes to launch. "That would cost on the order of $1 billion — maybe $500 million, maybe $1.2 billion," Worden says. With this laser launch prototype, Lubin says, "we can launch probes, place them in various Earth orbits, and possibly send them to the moon."
Once researchers finish extensively testing and experimenting with the prototype, they can build the final system, a laser array on the order of a square kilometer in size. The costs for the prototype and final systems will be huge, money that may come from private donors and perhaps from governments, Worden says.
Before *Breakthrough Starshot* begins an interstellar journey, it could launch interplanetary missions to explore mysterious corners of our solar system. "A very interesting intermediate mission would be to get a probe out to near-interstellar space and measure the particles and fields there," Worden says. "Today there's at least an order-of-magnitude level of uncertainty as to what the interstellar medium is like."

Current Staus (May 2019) [6 ff.]

The first human-made spacecraft to reach another star system might fit in the palm of your hand and weighs no more than a stick of gum. That's the design engineers from the University of California, Santa Barbara are working on.



A new spacecraft planned for interstellar travel weighs no more than 2-3 grams
Courtesy UC Santa Barbara

The tiny craft had its first test flight in April 2019, where it soared more than 100,000 feet in the air.
Its creators hope its successor will one day fly in space, perhaps even beyond the solar system to neighboring stars like Alpha Centauri. The test flight included some 4,000 images of Earth, and scientists imagine one day – perhaps within the next generation – sending back images of the Alpha Centauri system instead, complete with the planet, scientists think resides in the system.

The Santa Barbara group is planning a suborbital flight for the wafercraft as soon as next year (2020). In the meantime, there’s a lot of work left to do: the laser systems that would propel the craft to interstellar speeds don’t yet exist, and the current version of the craft isn’t likely to survive the harsh conditions of space: cold, filled with deadly radiation and highly charged particles – the downside to using standard equipment designed more for smart phones and watches than space travel.

But they’re not the only ones working on such technologies, with the eventual goal of propelling tiny spacecraft to superfast speeds toward neighboring star systems. In 2017, *Starshot* succeeded in sending six similarly tiny micro-craft into low-Earth orbit onboard a rocket — a higher flight achievement, but one accomplished with less technology on board each tiny spacecraft. “This experiment, the ones highlighted last year and a large number planned for the next few years are each designed to test an aspect of the technology,” Pete Worden, the Executive Director of *Breakthrough Starshot*, said in an email, calling each of the experiments “mutually supportive.”
In the shorter term, a simpler version of the *Starshot* technology could explore more local space near Mars or the asteroid belt, traveling faster and cheaper than standard exploratory missions. And in the long term, this craft or one like it just might send back our first close-up images of another star system.

The Editor’s conclusion is, that fundamental science for reaching Exoplanets should be kept going, however top priority should be to do everything possible to maintain the habitability of our planet Earth – it is the best option we have within the radius of 4.37 light years, and we are there already!

References

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