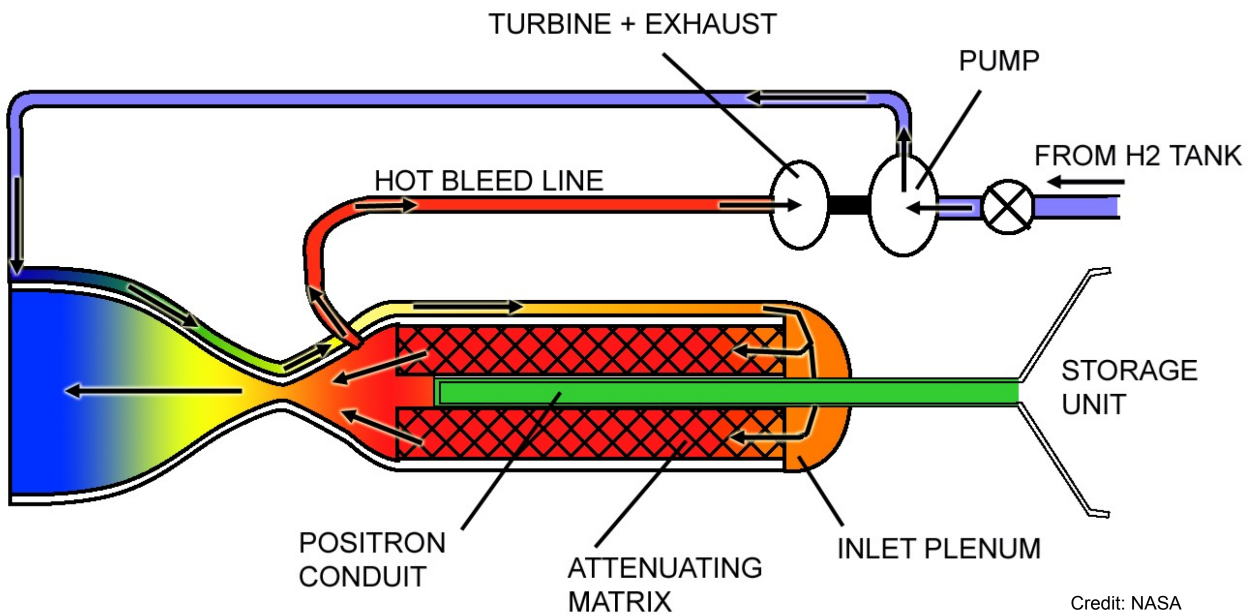
Science can amuse and fascinate us all, but it is engineering that changes the world.
Isaac Asimov

No Wormholes To Help

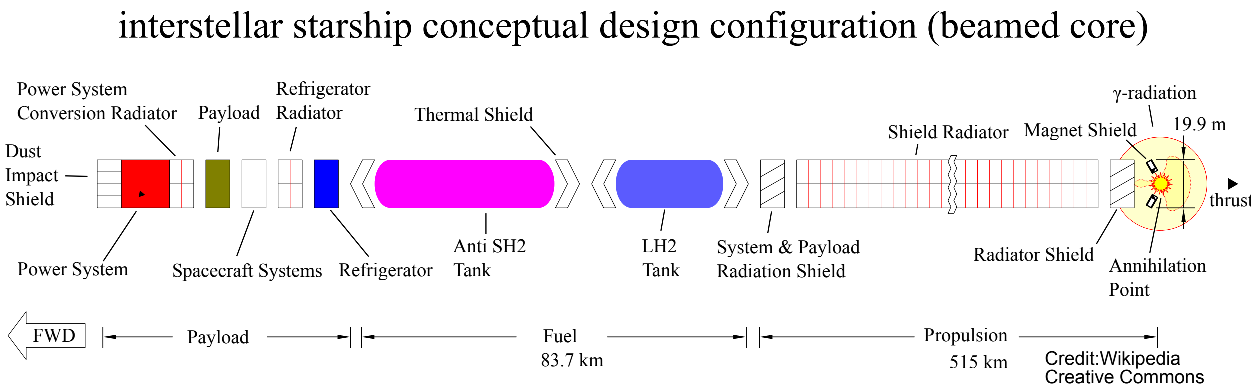
Hi AST 111. In this module we'll finish a two-part series on exploring space travel. Really, how difficult is interstellar travel?



As we've seen, fusion reactions convert about 1% of the mass into energy, which will get you to about 10% of the speed of light. Are there yet more powerful reactions? Matter-antimatter annihilation convert 100% of the mass into energy. That is, matter-antimatter reactions are 100 times more powerful than nuclear reactions. Matter-antimatter engines, such as the one illustrated above, could reach about 90% of the speed of light. Woohoo!

Antimatter. Let's say a few things about that. You know what an electron is - this is normal matter. The antimatter counterpart of the electron, the anti-electron if you like, is called the positron. A positron has the same properties as an electron except the positron has a positive electric charge instead the electron's negative charge. When a particle and its anti-particle meet they annihilate each other, completely converting all their mass into photons.

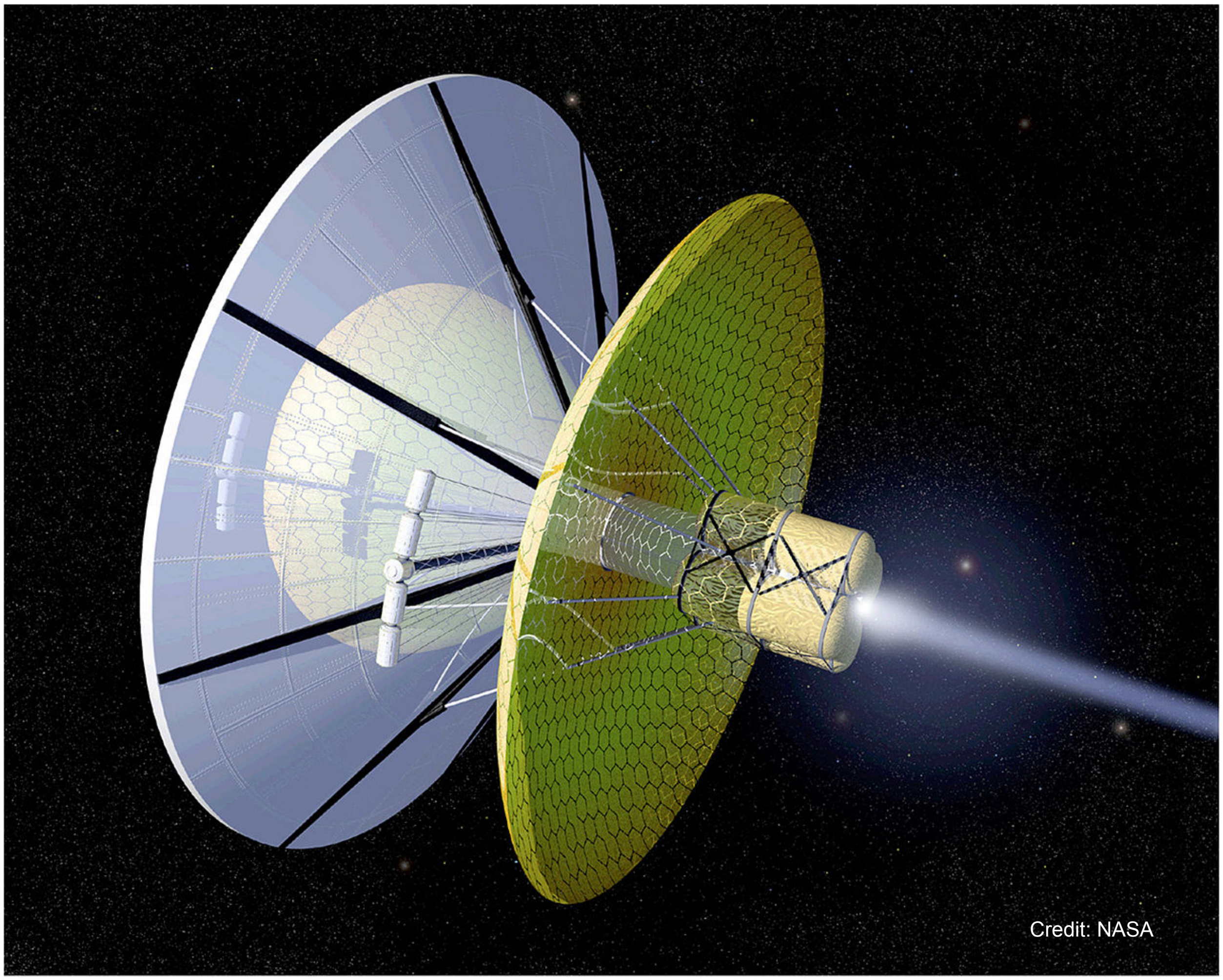
We live in a matter-dominated universe, but anti-matter does occur naturally. For example, radioactive potassium-40, used to date rocks and present in every banana you eat, emits a positron when it decays to argon-40. However, making just one kilogram of antimatter would take all the energy that humanity uses in one year. A trip to the nearest stars costs 10,000 kilograms of antimatter. So just the amount of energy that you have to put in to create the antimatter is prohibitive.



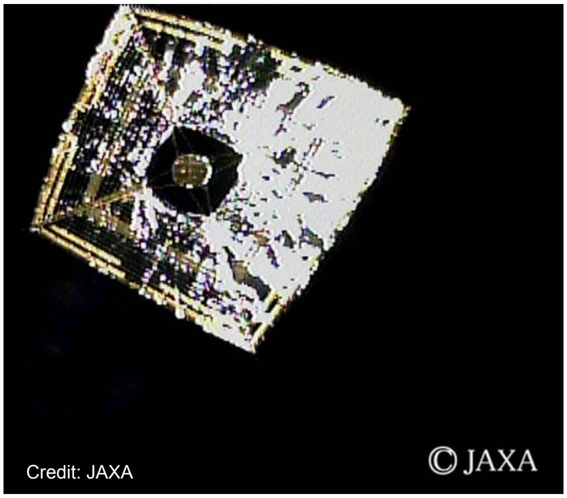
Storing antimatter for use in a rocket is especially challenging because if it touches any matter whatsoever, well, you'll have quite the explosion. Folks have considered magnetic bottles, but the bottle has to be 100% empty of ordinary matter. Otherwise, Bang!

A problem for chemical, nuclear, or matter-antimatter rockets is simply carrying enough fuel to reach the nearest stars, much less come back. There are no NASA gas stations, like the one above, in space.

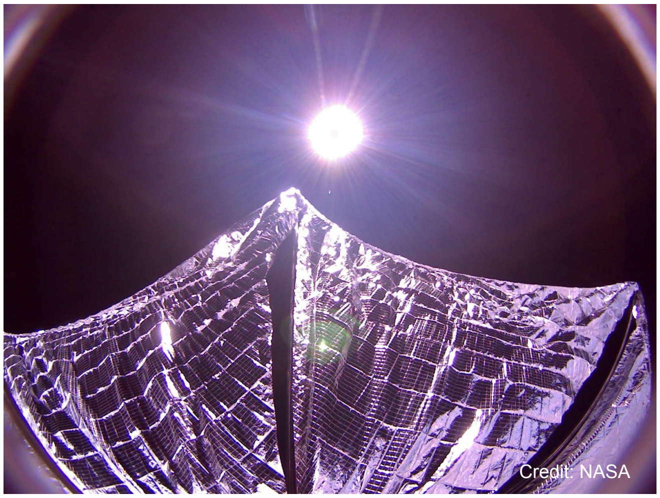
How to get around the no gas station problem? Well, collect it as you go! One rendition of this idea is called the Bussard Ramjet, and example of which is shown below. You have a big scoop in front of your spacecraft to pick up those lonely hydrogen atoms that dominate the composition of the universe.You use these hydrogen atoms in nuclear fusion engine. The number of protons that can be scooped up by the sail and the drag created by scooping them up limits such ramjets to about 25% of the speed of light. But, no need for a refueling station. A big advantage.

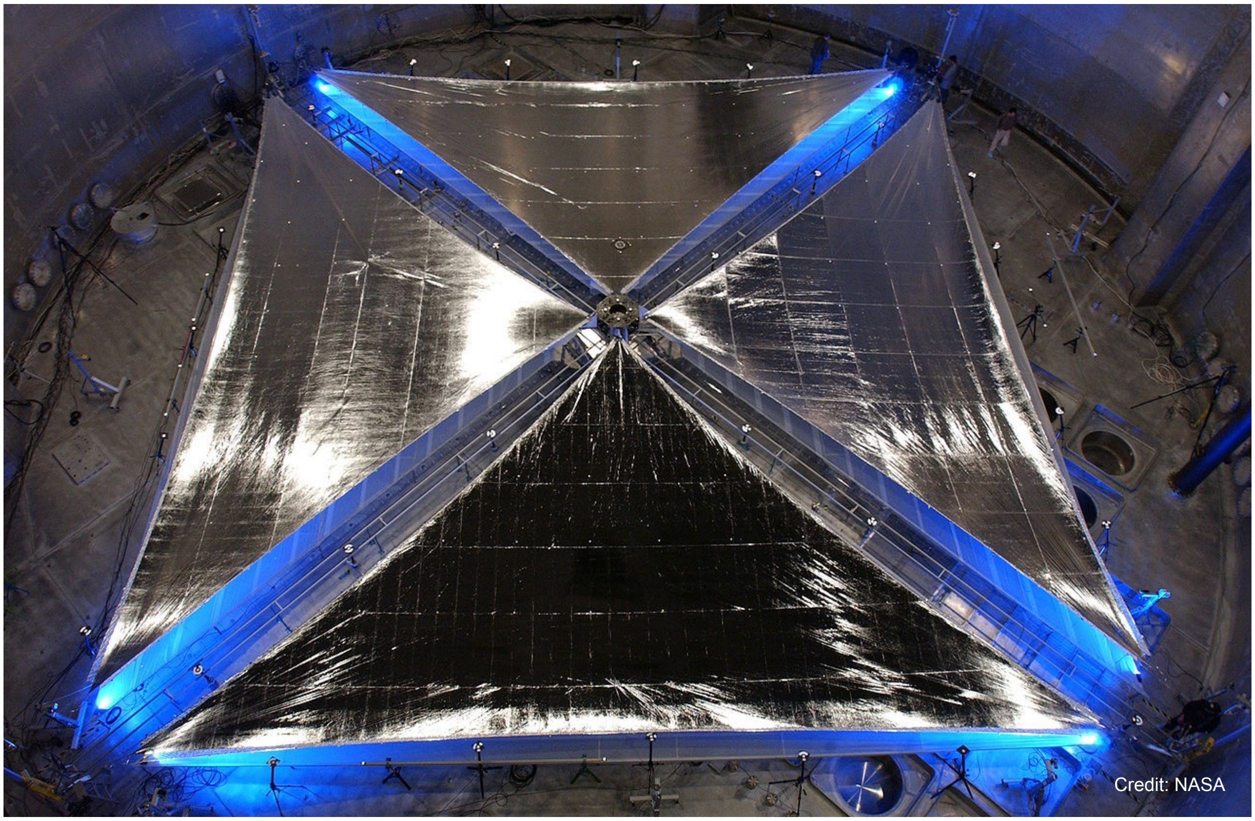

Credit: NASA

Another idea is rather than use a material fuel, use light! Because when light strikes an object, it pushes on it ever so slightly. Newton's third law. If you collect a lot of light over a large enough area, the forces can useable. Such sails could reach 50% of the speed of light, and again no need for a refueling station. The original idea of light sails was advanced by Rob Forward who envisioned using a super powerful laser on a sail. Not so practical, but the idea of using light sails is not fantasy. They have flown and more tests are coming. For example the lect image below shows the IKAROS kite-craft in flight. IKAROS was launched in May 2010 and in December 2010 passed by Venus. It was the first spacecraft to use solar sailing as the main propulsion. In May 2015 the LightSail-A was launched. Despite some initial software malfunctions and battery problems, by June 2015 it deployed its solar sail, flew for a bit and then reentered the atmosphere. In April 2016 the much larger LightSail-1 launches. The image below shows its approximately 30 square meter sail. The goal is to measure if there is any increase in orbital speed after the spacecraft deploys its sail at an altitude of about 1000 km.

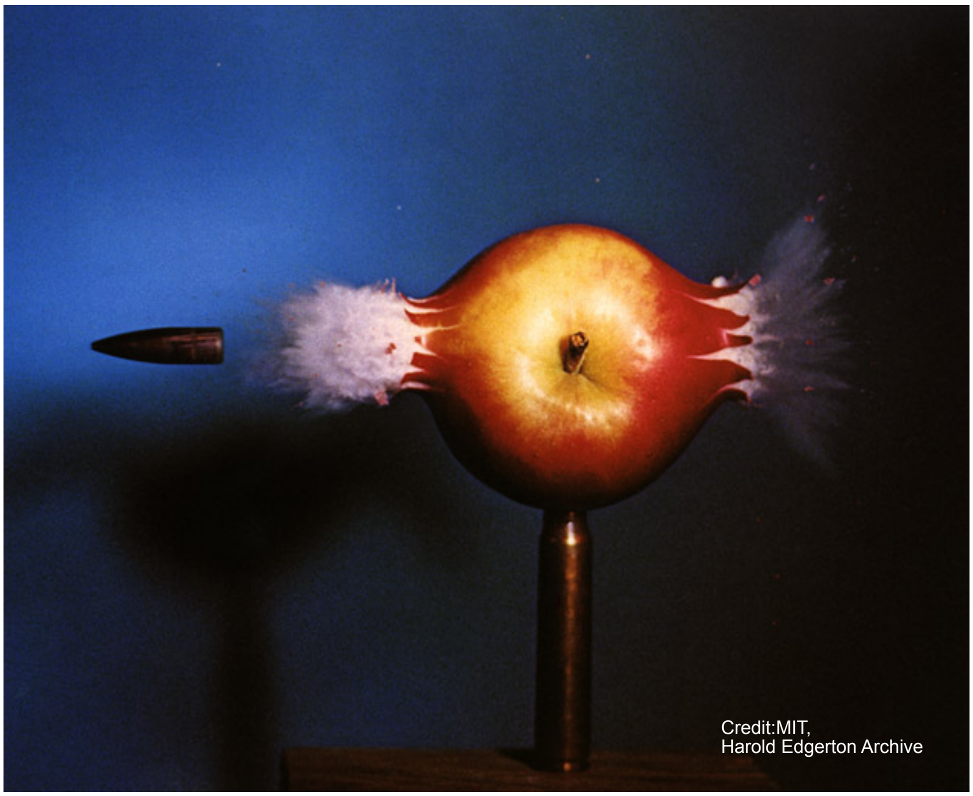


Credit: JAXA


Credit: NASA


Credit: NASA

Speaking of increasing speed, another difficulty at traveling at the speed of light is every little gas or dust particle becomes a bullet of enormous energy. The image below is from the earliest days of strobe photography. The apple is the spacecraft and the gas particle is the bullet. You're going to have to have some way of clearing the path before you go through, sort of like a cow catcher in front of a railroad engine.



Robots avoid a lot of the difficulties that humans face. Humans need food, oxygen, and controlled temperatures. Humans come with a lot of stuff to carry around. You can get away from much of that if you use robots. They can be made far smaller and less expensive. They could travel at lower speeds because they don't have the requirement of getting there and back within a human lifetime. Thousands could be made with each one sent to a different target. Two famous space faring robots are shown below.

Some people assume that interstellar space travel will soon become a human reality, probably because our art is very persuasive and motivating. But science of it says interstellar space travel will remain incredibly difficult for the foreseeable future. That does not say impossible. Echoing our opening quote, its engineering that changes the world.

Thanks! Bye Bye.