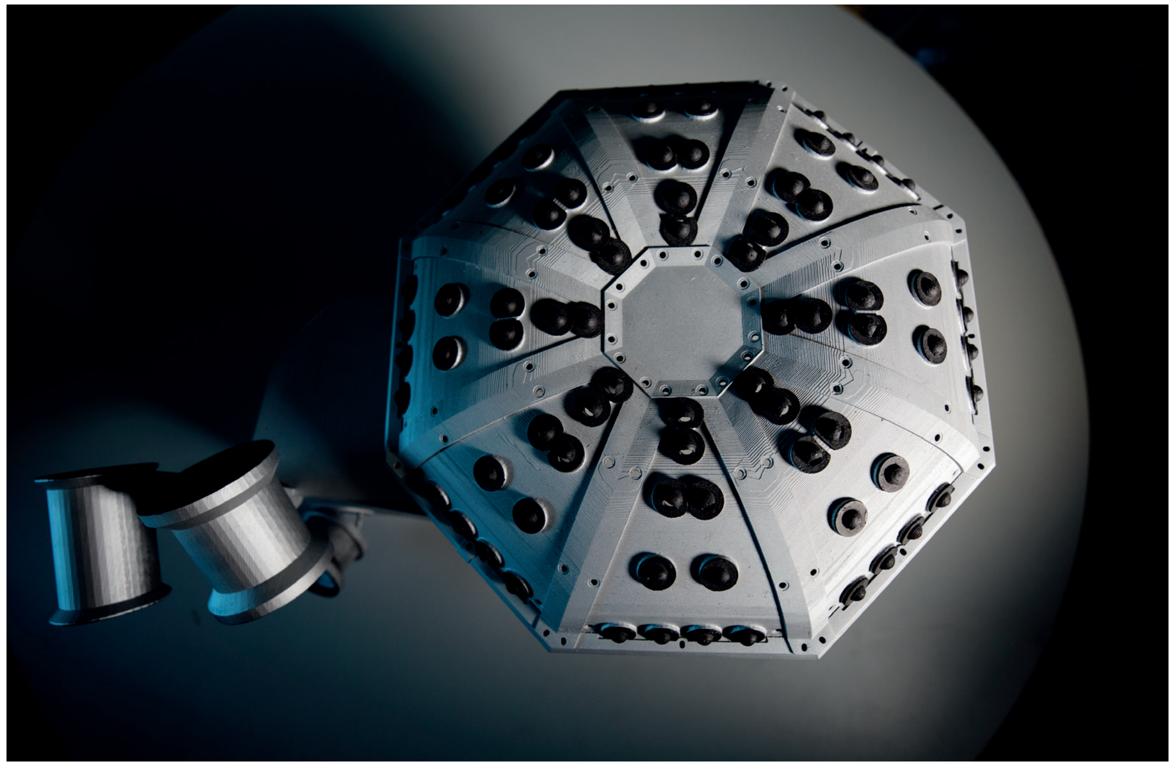
MISSION ICARUS

The Parker Solar Probe is about to take us closer to the sun than ever before. It's an audacious mission that will test technology – and the nerves of the scientists behind it – to the limit

Interviews by ***Richard Webb****. Photos by* ***Michael Soluri***



Our sun is no serene orb. Every now and then its fiery surface turns explosive, sending matter, energy and magnetism whirling into the surrounding vacuum.

In 1859, a particularly violent solar flare-up coincided with a huge electromagnetic storm in Earth's atmosphere. The interference caused polar auroras that could be seen as far south as the Caribbean and as far north as Auckland, New Zealand, and knocked out telegraphic systems.

That was when we first grasped the power of solar storms on Earth. But what caused them remained unknown. In 1956, ***Eugene Parker****, a young postdoc at the University of Chicago, was investigating cosmic rays arriving at Earth from far off in the galaxy when an idea struck him.*

We knew cosmic rays were correlated with the sun's magnetic activity, but the timing of the cosmic rays on our detectors during one particularly violent solar flare showed that the particles were moving very freely from sun to Earth. Around the same time, astronomers were noting that comet tails always pointed away from the sun, and that, too, was very difficult to explain.

One day in 1958, it occurred to me this was all very simple. The sun's atmosphere, the corona, is not tightly bound. Stuff can escape, and the whole thing acts like one big gaseous outward wind. It starts off very slow, but gets faster and faster, and by the time it's out at Earth, it's supersonic. It sweeps cosmic rays to Earth – and blows the comet tails in the opposite direction.

I came in for a lot of flak for the idea, but no one could find anything wrong with the mathematics. Then, in 1962, they launched Mariner 2 to Venus, the first mission into interplanetary space. What it saw could hardly be denied. The transformation was very quick: people were saying we always knew there was a solar wind. You know how it goes. I never criticised.

Previous page: The Parker Solar Probe being tested at the Goddard Space Flight Center in Maryland

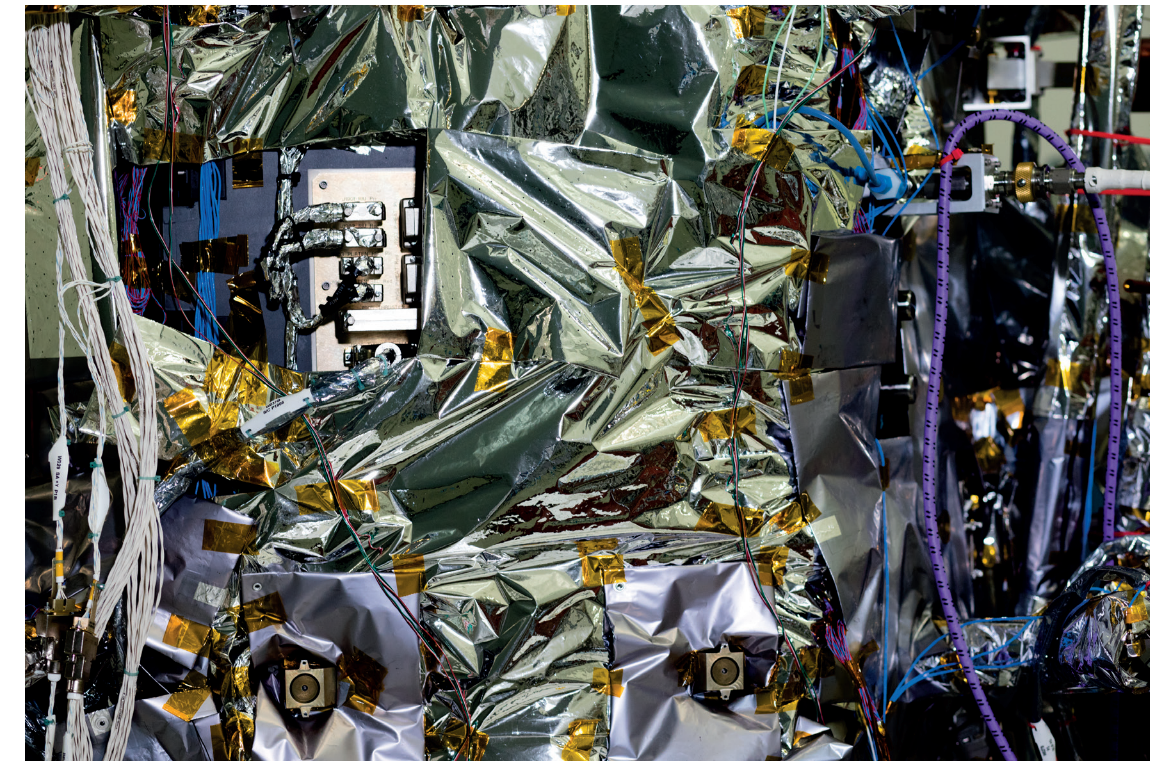
Above: A mock-up of the instrument that will observe how electrons, protons and ions behave in the sun's atmosphere

6.2 million km

The closest the Parker Solar Probe will get to the sun, or about 10 solar radii away

1400°C

The temperature the probe will feel on its sun-facing side at its closest approach



Above: A silver blanket covering the probe will protect its instruments from the sun. One of its two solar panels will attach to the pair of mounts at the bottom of the shot

Fears of a repeat of the 1859 storm – one that might wreak havoc with modern power systems, satellites and communications networks – fuelled a growing desire to take a closer look at the solar wind, says Parker Solar Probe project scientist ***Nicola Fox****.*

The birthplace of the solar wind – the sun's atmosphere or corona – must be super-energised. In fact, it must be 300 times hotter than the sun's surface. That defies the laws of nature: you shouldn't have a heat source that gets hotter as you move away from it. There's some additional energy, some black magic going on in this region, and it's causing the solar wind to say, I'm off.

The solar wind doesn't just break away from the sun, it carries the sun's magnetic field with it somehow. Whatever state the field is in, whatever direction, however strong it is, it is frozen into the solar wind. That's what impacts Earth. When the activity's high, that makes solar storms.

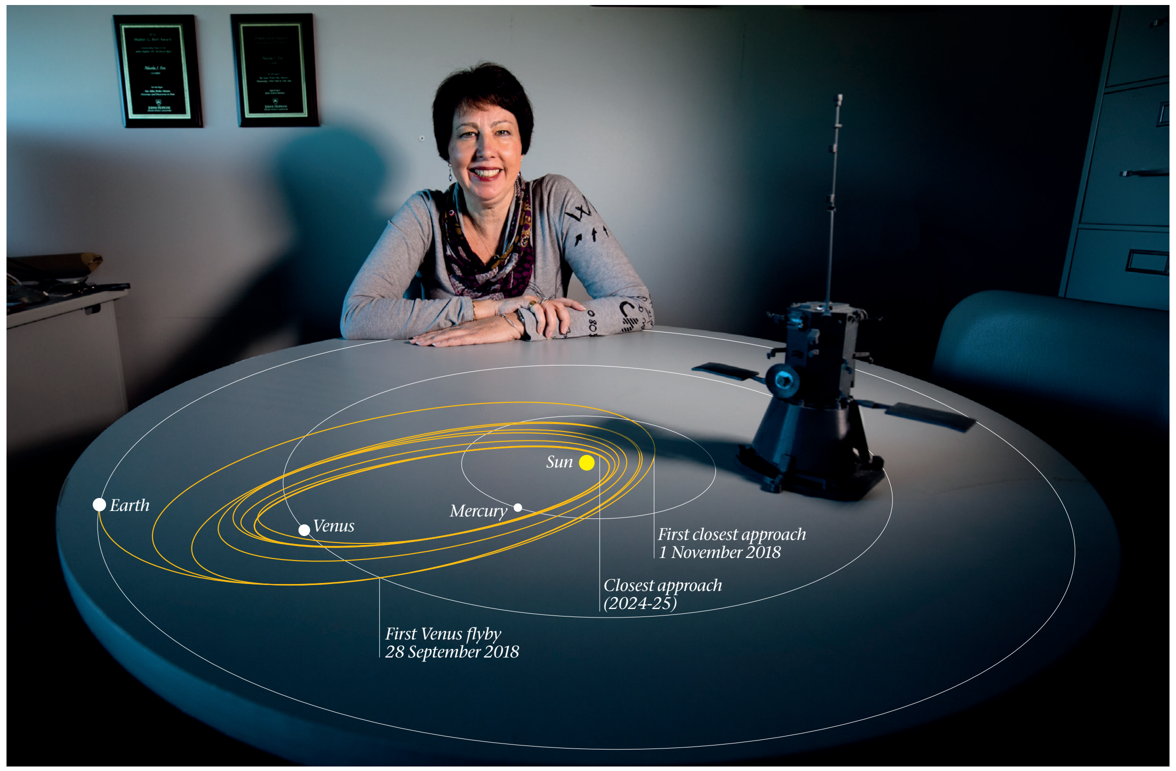
The details of this process remained enigmatic, and various missions were planned to fly into the solar wind to investigate. In 1976, the Helios-B spacecraft made it to within 60 solar radii [or 42 million kilometres] of the sun's surface, inside Mercury's orbit. But there was a fundamental technological barrier to getting any closer: no material existed that was lightweight yet heat-resistant enough to shield the probe's instruments from the sun, says engineer ***Andy Driesman****.*

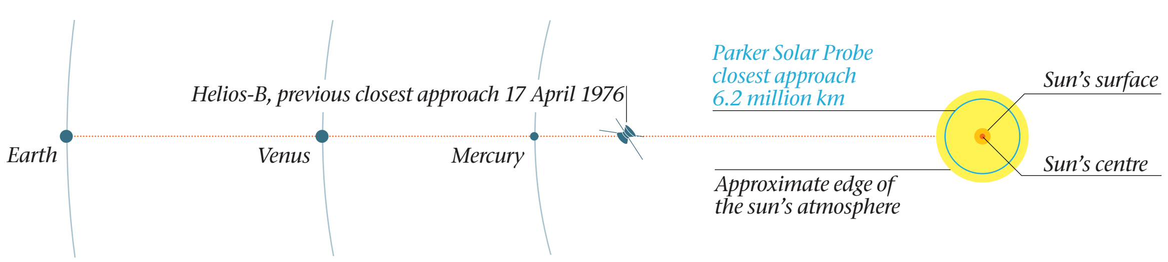
As close to the sun as we wanted to get the probe, there would be almost 3 million watts of heat energy on its front surface, and we had to make sure there would only be 30 watts on the back side. There are some high-temperature metals that could make the protective shield, but they are too heavy to launch.

The magic material is carbon. In the 1980s, you began to see carbon technologies in your golf clubs and tennis rackets. In the early 2000s, we took things one step further, making carbon materials light enough and strong enough to withstand the sun's heat, and coating them so they are not so black and absorb less heat.

Carbon is very brittle and fragile, and a lot of work went into making a heat shield that could survive the launch environment. When we finally thought we had a solution, we went back to NASA and NASA said, OK, go forward, you're now a mission.

The Solar Probe Plus mission, approved in 2009, looked very different from previous proposed sorties to the sun. That was down to





a shortage of plutonium radioisotope fuel for nuclear-powered spacecraft, which led NASA to favour purely solar-powered missions – and ironically that becomes a particular problem when you want to visit the sun. Mission scientist ***Yanping Guo*** *had to find a way to solve it.*

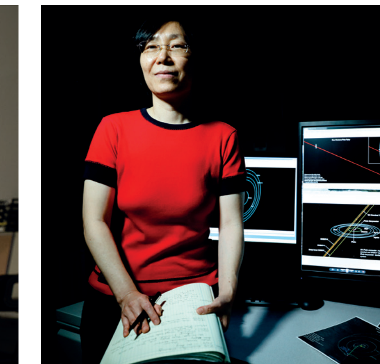
When you launch a spacecraft from Earth, it possesses Earth's orbital velocity, about 30 kilometres a second. To get to the sun, you have to cancel out most of that, slow it down so it can fall in under gravity. That takes a lot of energy. If you want to launch directly from Earth to the sun, you need 55 times more energy than to get to Mars. It's more than twice even what you need to get to Pluto.

For five decades, we had been studying this problem on and off, and had come to the same conclusion: to get to the sun you need a Jupiter gravity assist. Instead of going directly to the sun, you launch out to Jupiter, and use its gravity to reduce the spacecraft's speed so it falls inwards.

But at Jupiter's distance, solar power won't work: you need nuclear. Everyone said the problem was impossible, but I started looking at whether you might use the gravity of the inner planets instead. Venus is much smaller than Jupiter, so its gravity assist is much less. You can

Above: To get within the sun's atmosphere, the probe will have o loop round Venus seven times, using the planet's gravity to slow it down so it can fall into orbit around the sun. The different orbital periods mean the probe has to go round the sun several times between gravity assists, getting closer to its target each time

Photos, clockwise from above: Nicola Fox, project scientist for the probe. Test engineer Annette Dolbow. Yanping Guo, who devised the novel trajectory for the probe. Andy Driesman, engineer



flyby multiple times, each time losing some velocity and falling in closer to the sun, but that means manoeuvring to pass Venus in the right orbit each time, which is tricky and uses up fuel.

Eventually, I found a trajectory with seven Venus assists that passes the sun 26 times, each time closer. The closer the probe falls, the faster it gets. At its fastest, it will be travelling at 200 kilometres a second – the fastest spacecraft ever.

In May 2017, NASA renamed the probe after ***Eugene Parker****. Now 90 years old, he became the first living scientist to be so honoured.*

I was invited to have a look at it. It's quite a monstrosity. When I came out with the theory 60 years ago, I never thought about whether it would be possible to get that close to the sun, because I didn't know what the limits were. But after those years of people being sceptical at the beginning, I feel very good. With instruments right up there in the solar wind, we will be able to measure it directly, and all the speculation will be over.

The probe is scheduled for launch on 31 July – the tensest time for the mission team, says ***Andy Driesman****.*

It's like having a baby. You read the books and you see the kids around you, so you know how it's done and what to expect, but nothing prepares you for that moment. You have built this thing, you have designed it, you have tested the heck out of it and then you launch it. You are in the hands of a fiery beast and you have 60 minutes with no control whatsoever. And then you make first contact after launch and you catch a breath of relief because now you've got control again. You can talk to the thing, you can understand what is going on.

After it arrives at the sun in November, the probe will fly past it a further 25 times over seven years, getting closer each time. With each pass, its measurements of fluctuating magnetic fields and fast-moving charged particles in the sun's corona will give us further insights into what makes the solar wind. That's when things get interesting, says ***Nicola Fox****.*

The most exciting thing will be our first closest approach. Even though it won't be at the ultimate goal of 10 solar radii – it will be out at about 35 solar radii – it is still way closer than anyone has been before. We are going to be in uncharted territory, a "here be dragons" space. Just that is exciting – to be somewhere no one has been before. Even so, the idea of never seeing her again is traumatic. It's a little bit like sending your kids to college – you have brought them up and all you can do now is hope you have brought them up right, and hope they write. ■

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