In the blazing inferno of the Sun

They looked liked oversized spools of thread, were packed full of technology from various Max Planck Institutes, and aimed to considerably improve our understanding of the Sun and the interplanetary medium: over 40 years ago, the two ***Helios* probes** were launched on a daring mission to the searing heat of our home star. However, the two spacecraft were also a symbol of successful scientific collaboration across national borders.

TEXT **HELMUT HORNUNG**

The date is the 10th December 1974, Launch Complex 41, Cape Canaveral in the U.S.: a *Titan 3E Centaur* towers above the launch pad. The countdown goes according to schedule. When it reaches zero, the rocket is shrouded in white smoke and seconds later disappears into the Florida sky, leaving behind a trail of fire. The engines accelerate the launch vehicle to an immense speed of over 14 kilometers per second, which is necessary to deliver the precious cargo in the nose cone safely to its destination – close to the Sun itself. The cargo in question is the *Helios 1* space probe, and American and German researchers have high hopes for the mission.

It all began back in 1966, when German Chancellor Ludwig Erhardt and U.S. President Lyndon B. Johnson signed an agreement to conduct a joint mission in our solar system. The two countries were anything but equal partners: on the one hand, the Americans were racing the USSR to the Moon at the height of the Cold War and had already achieved considerable success in relation to space travel; on the other, the Germans had practically no experience in this area and hadn't yet built a single probe of their own.

At first, the mission's destination was deliberately left open. That was a question for the scientists to worry about. This was where the then Max Planck Institute for Physics came in. In the early 1950s, the Institute's Astrophysics Department was led by Ludwig Biermann. The fact that comet tails always have a similar shape led the researcher to conclude that the Sun must constantly emit an invisible stream of electrically charged particles into space. Indeed, the Soviet *Luna 1* probe managed to detect this so-called "solar wind" on its way to the Moon in 1959; the wind was primarily made up of protons and electrons, as well as helium-4 nuclei. Now, a decade later, the plan was to take a more detailed look at the solar wind and conditions close to the Sun, as well as analyzing the interactions between the central star and our planet.

In June 1969, the mission agreement was officially ratified and fleshed out in more detail. Two more or less identical probes would be fired into space. They were named after Helios, the Greek god who rides his sun chariot – drawn by four fiery stallions – across the sky every day and bestows light and heat upon the Earth.

The probes were built by Messerschmitt-Bölkow-Blohm, acting as the main contractor, in close collaboration with the German Federal Ministry of Research and Technology and the German Test and Research Institute for Aviation and Space Flight. Seven of the ten experiments on board were developed by German scientists, and four measuring instruments originated from the Max Planck Institutes for Aeronomy, Astronomy, Nuclear Physics, and Extraterrestrial Physics. The U.S. National Aeronautics and Space Administration (NASA) supplied the two launch vehicles and made its Deep Space Network available for communicating with the probes. The project cost 700 million marks in total, of which the Germans contributed 450 million.

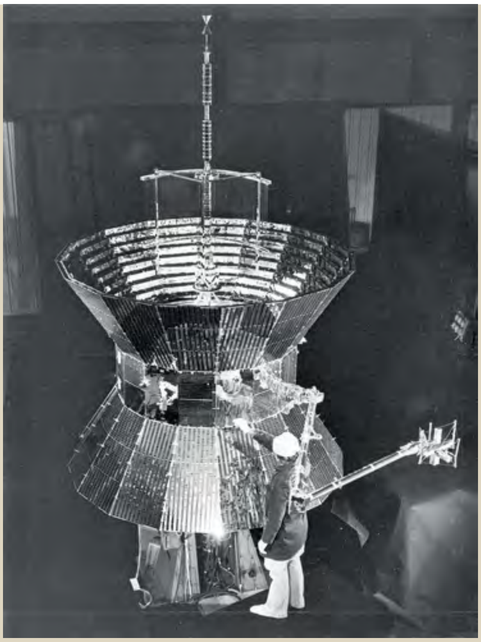
For West Germany, this was not simply about scientific know-how. In the early 1970s, the country was also keen to expand its knowledge of technology and the management of large-scale projects, with the aim of one day being able to conduct national and international research programs successfully. With *Helios*, those responsible were therefore entering uncharted territory in every respect.

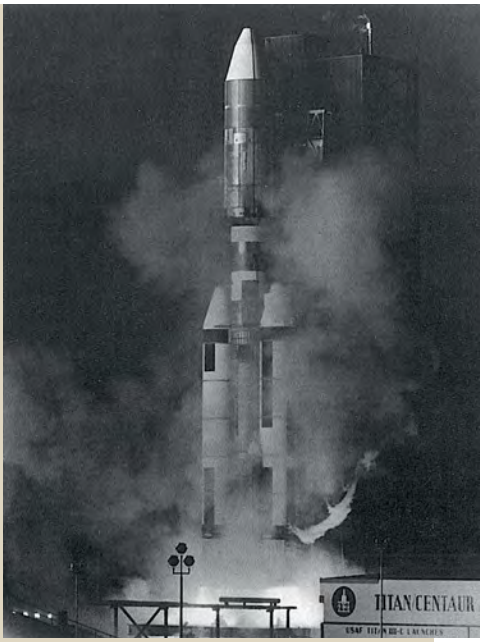
"It was a bold plan, carried out without a great deal of risk assessment," recalls Eckart Marsch. The physicist joined Helmut Rosenbauer's group at the Max Planck Institute for Extraterrestrial Physics as a postdoc in 1976 and spent the next few years working on the analysis of data from the plasma experiment and the instrument for magnetic field measurements. Even the orbits represented a risk, as they brought the probes to within 50 million kilometers of the Sun. At this distance, the terrestrial scouts were exposed to eleven times as much heat as the Earth and reached temperatures in excess of 350 degrees centigrade – hotter than the melting point of lead.

"The shape of the probes was designed based on thermal engineering considerations," says Marsch. In brief, the "spools of thread" were two meters high, weighed 370 kilograms, and were

Left An oversized spool of thread: the shape of *Helios* was designed based on thermal engineering considerations. The outer body of the probe is alternately covered with special mirrors and solar cells that supply the spacecraft with energy.

Right A successful start: the *Titan 3E Centaur* rocket lifts off punctually to deliver *Helios 1* to its destination close to the Sun. The mission is a huge success, as is that of the twin probe, *Helios 2*. A third probe was also built, but this was not launched into space and instead ended up in the Deutsches Museum in Munich.





covered with optical reflectors – known as “cold mirrors” – that reflected around 90 percent of the incident light back into space. The entire underside of the skin was lined with insulation. Lastly, the spools of thread rotated about their axes once a second in order to distribute the incident heat evenly over the surface and avoid “sunburn”. With all of these design measures, the spacecraft were so well insulated that the inside temperatures never rose above 30 degrees centigrade, and the probes even needed to be heated while at the furthest point of their orbit from the Sun.

After a smooth launch and a three-month journey through the solar system, *Helios 1* (denoted by some authors as *Helios A*) reached the closest point of its orbit to the Sun (“perihelion”) on 15 March 1975. Moving at a record speed of over 252,000 kilometers per hour, the probe raced past the Sun at a distance of 46.29 million kilometers, approximately a third of the distance between the Earth and the Sun. Two days later, the scientists working under the project leader Herbert Porsche at the control center in Oberpfaffenhofen expressed their satisfaction. “All of the probe’s components are working perfectly,” Porsche said at the time. Helios was, he said, exceeding expectations “including in terms of the quality of the data.”

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» With surprise and astonishment, the participating scientists tracked the German-American solar probe *Helios* as it completed its flyby of the Sun.

A press conference was hastily convened to present the initial scientific findings. For example, the solar wind was stronger than expected, moving through interplanetary space at speeds of up to 850 kilometers per second with relatively large fluctuations in intensity and showing exceptionally rapid temporal and spatial variations. It was also considerably warmer than assumed and followed a 27-day cycle corresponding to the rotation of the Sun. Close to the star, the number of interplanetary dust particles increased tenfold relative to that encountered at Earth’s orbital radius. And the “protective wall” of the solar magnetic field was so dense that the low-energy cosmic radiation couldn’t penetrate it.

Helios 1 also specifically examined zodiacal light – a diffuse light that can be observed at our latitudes after sunset in the west or before sunrise in the east. This phenomenon is attributed to the reflection and scattering of sunlight by particles in the interplanetary dust and gas cloud, which forms a ring-like disk around the Sun in the ecliptic plane. As the probe approached the Sun, the on-board “Experiment 9” did not record a significant change in the color of zodiacal light. This confounded expectations, leading the researchers to conclude that the particles, which are only a few thousandths of a millimeter in size, do not get smaller near the Sun. However, the brightness of the zodiacal light was shown to increase 15-fold relative to that observed on Earth.

Exactly ten months after this spectacular rendezvous at the heart of the solar system came the launch of the twin probe, *Helios 2* (*Helios B*). With a perihelion of 43.5 million kilometers, the second probe managed to get even closer to the Sun than *Helios 1*, if only slightly. For this probe, too, communication took place via the three large 64-meter antennas of the NASA Deep Space Network, the 100-meter dish of the Max Planck Institute for Radio Astronomy in Effelsberg, in the Eifel mountains, and – as a transmitting station – the 30-meter antenna in Weilheim, Upper Bavaria.

This was the first ever double mission of its kind. “However, it was also unique because no mission before or after it has ever taken in situ measurements so close to the Sun,” says Eckart Marsch, adding that the mood in the Helios team was buoyed by this success. The lifespan of the probes was also impressive: originally designed to last 18 months, *Helios 2* continued operating until December 1981, and *Helios 1* until March 1986 – that is, for over ten years. “Strictly speaking, the mission isn’t even dead yet,” says Marsch. "After all, the scientific data is still being analyzed today, for example, at Kiel University."

Indeed, no other space probe in the past 40 years has flown as close to the Sun as Helios. However, this is set to change: on 12 August 2018, NASA launched the *Parker Solar Probe*. After a series of complicated orbital maneuvers over the next few years, the probe will approach the Sun to a distance of just over six million kilometers, from where it will study the outer layers of its atmosphere. Early November this year already saw the spacecraft approach to within around 25 million kilometers, breaking the record of the legendary *Helios* scout.

Photos: MBB (left); NASA (right)