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THE SURVEY OF PARKER SOLAR PROBE

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ABSTRACT

NASA's Parker Solar Probe mission will revolutionize our understanding of the Sun. The mission will "touch the Sun," flying directly through the solar corona, facing brutal heat and radiation conditions and providing unprecedented, close-up observations of the star we live with. These observations will address unsolved science questions such as how the Sun's corona is heated and how the solar wind is accelerated. It will also benefit humans on the ground by making critical contributions to our ability to forecast major space weather events that impact life and technology on Earth. Such information can shed light not only on how the Sun drives the space environment in our own solar system, but also provide insight into other stars throughout the universe. In this paper we summarize the development of solar probe including working, assembly, inspection and maintenance.

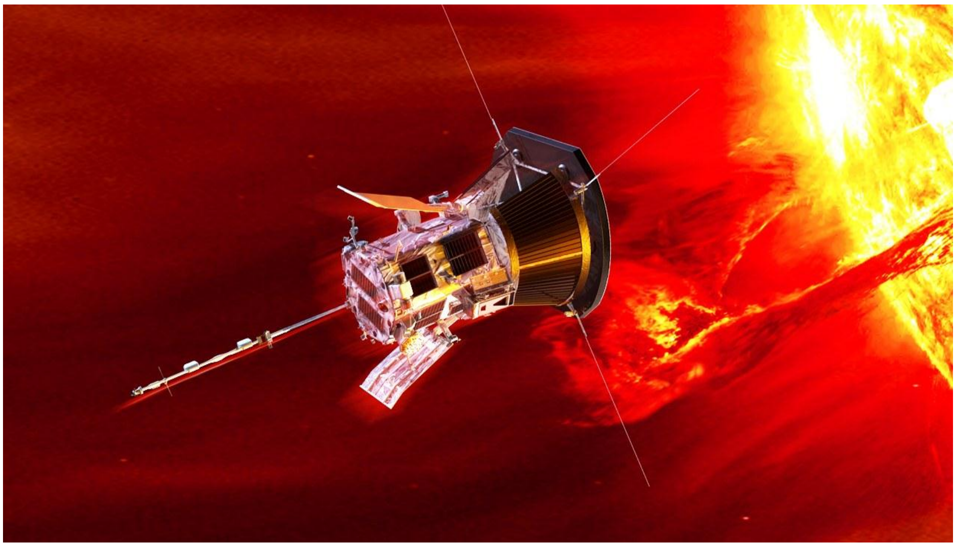
KEYWORDS: Solar corona, solar probe, space weather.

INTRODUCTION

Parker solar probe (previously Solar Probe, Solar Probe Plus, or Solar Probe+, abbreviated PSP) is a NASA robotic spacecraft launched in 2018 and currently en route to probe the outer corona of the Sun. It will approach to within 9.86 solar radii (6.9 million kilometers or 4.3 million miles) from the center of the Sun and by 2025 will travel, at closest approach, as fast as 690,000 km/h (430,000 mph), or 0.064% the speed of light.

The project was announced in the fiscal 2009 budget year. The cost of the project is US$1.5 billion. Johns Hopkins University Applied physics laboratory designed and built the spacecraft, which was launched on August 12, 2018. It became the first NASA spacecraft named after a living person, honoring physicist Eugene Parker, professor emeritus at the University of Chicago. The Parker Solar Probe concept originates from a predecessor Solar Orbiter project conceived in the 1990s. Similar in design and objectives, the Solar Probe mission served as one of the centerpieces of the eponymous Outer Planet/Solar Probe (OPSP) program formulated by NASA. The first three missions of the program were planned to be: the Solar Orbiter, the Pluto and Kuiper belt reconnaissance mission Pluto Kuiper Express, and the Europa Orbiter astrobiology mission focused on Europa.

The original Solar Probe design used a gravity assist from Jupiter to enter a polar orbit which dropped almost directly toward the Sun. While this explored the important solar poles and came even closer to the surface (3 $R_{\odot}$, a perihelion of 4 $R_{\odot}$), the extreme variation in solar irradiance made for an expensive mission and required a radioisotope thermal generator for power. The trip to Jupiter also made for a long mission (3 ½ years to first solar perihelion, 8 years to second).



Objectives

- To understand the concept of solar probe
- Familiarize yourself with parts of solar probe.
- To know about solar corona.

Why Parker Solar Probe?

As we know, we live in sun's atmosphere. So this mission will help us to know about the connection in the Sun and the Earth.

Because, still there is some mystery about the sun so we have to go closer to our star.

Solar Corona

At times of total eclipse, observations of the corona are possible because radiation from the solar disk is masked by the Moon. What is normally observed is the so-called K-corona. The white light from the corona is due to Thomson scattering of photospheric light by free electrons in the coronal plasma. The intensity ratio of light from the corona (close to the solar surface) to light from the photosphere is less than 10-5; this is why the corona can only be seen when the solar disk is blocked out. The visible structure of the corona during eclipses is due to the variations of the total electron content in the corona, i.e. the integrated electron density along the line-of-sight.

A corona (Latin, 'crown') is an aura of plasma that surrounds the Sun and other stars. The Sun's corona extends millions of kilometers into outer space and is most easily seen during a total solar eclipse, but it is also observable with a coronagraph. The word corona is a Latin word meaning "crown", from the Ancient Greek korone (korōnè, "garland, wreath").

Spectroscopy measurements indicate strong ionization in the corona and a plasma temperature in excess of 1,000,000 kelvins, much hotter than the surface of the Sun. Light from the corona comes from three primary sources, from the same volume of space.

The K-corona (K for kontinuierlich, "continuous" in German) is created by sunlight scattering off free electrons; Doppler broadening of the reflected photospheric absorption lines spreads them so greatly as to completely obscure them, giving the spectral appearance of a continuum with no absorption lines. The F-corona (F for Fraunhofer) is created by sunlight bouncing off dust particles, and is observable because its light contains the Fraunhofer absorption lines that are seen in raw sunlight; the F-corona extends to very high elongation angles from the Sun, where it is called the zodiacal light. The E-corona (E for emission) is due to spectral emission lines produced by ions that are present in the coronal plasma; it may be observed in broad or forbidden or hot spectral emission lines and is the main source of information about the corona's composition.

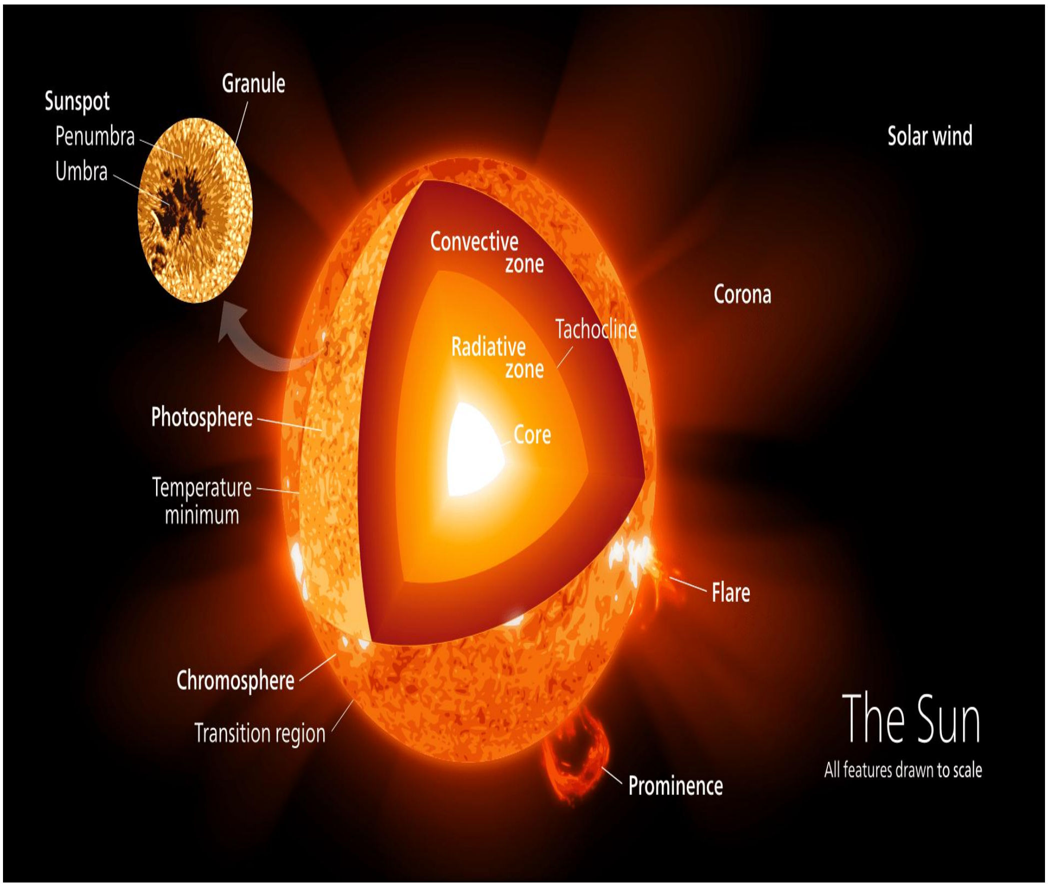


Fig 2.1: Sun's Corona.

Features occurring above the Sun's surface (photosphere)

Table 2.1: Features occurring above the Sun's surface (photosphere).

Chromospheric features	**Coronal features**
Chromospheric Network web like pattern formed by magnetic field lines related to super granules **Plage** bright patches surrounding sunspots and associated with concentrations of magnetic field lines **Prominences/Filaments** dense clouds of material suspended above the surface of the Sun by magnetic field line loops, called prominences when seen on the limb of the Sun, otherwise filaments; can remain quiet for days or weeks, but can also erupt within few minutes **Spicules** small, jet-like eruptions in the Chromospheric network lasting a few minutes only **Solar flares** huge explosions with time scales of only a few minutes	**Coronal Holes** source of high-speed solar wind **Coronal Loops** closed magnetic field line loops around sunspots and active regions; can last for days or weeks if not associated with solar flares Coronal Mass Ejections (CMEs) huge bubbles of gas ejected from the Sun over the course of several hours **Helmet Streamers** source of low-speed solar wind; network of magnetic loops with dense plasma connecting the sunspots in active regions, typically occurring above prominences **Polar Plumes** long thin streamers associated with open magnetic field lines at the poles

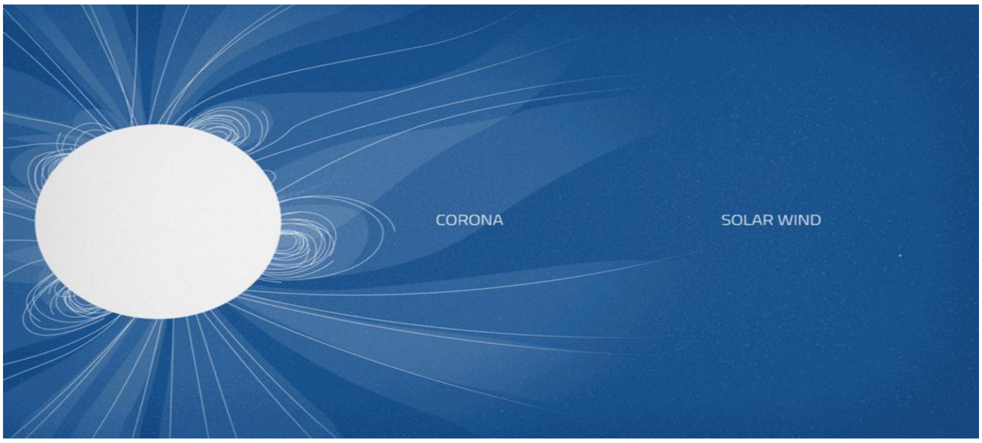


Fig. 2.2: sun's corona and solar wind.

Spacecraft

The Parker Solar Probe will be the first spacecraft to fly into the low solar corona. It will assess the structure and dynamics of the Sun's coronal plasma and magnetic field, the energy flow that heats the solar corona and impels the solar wind, and the mechanisms that accelerate energetic particles.

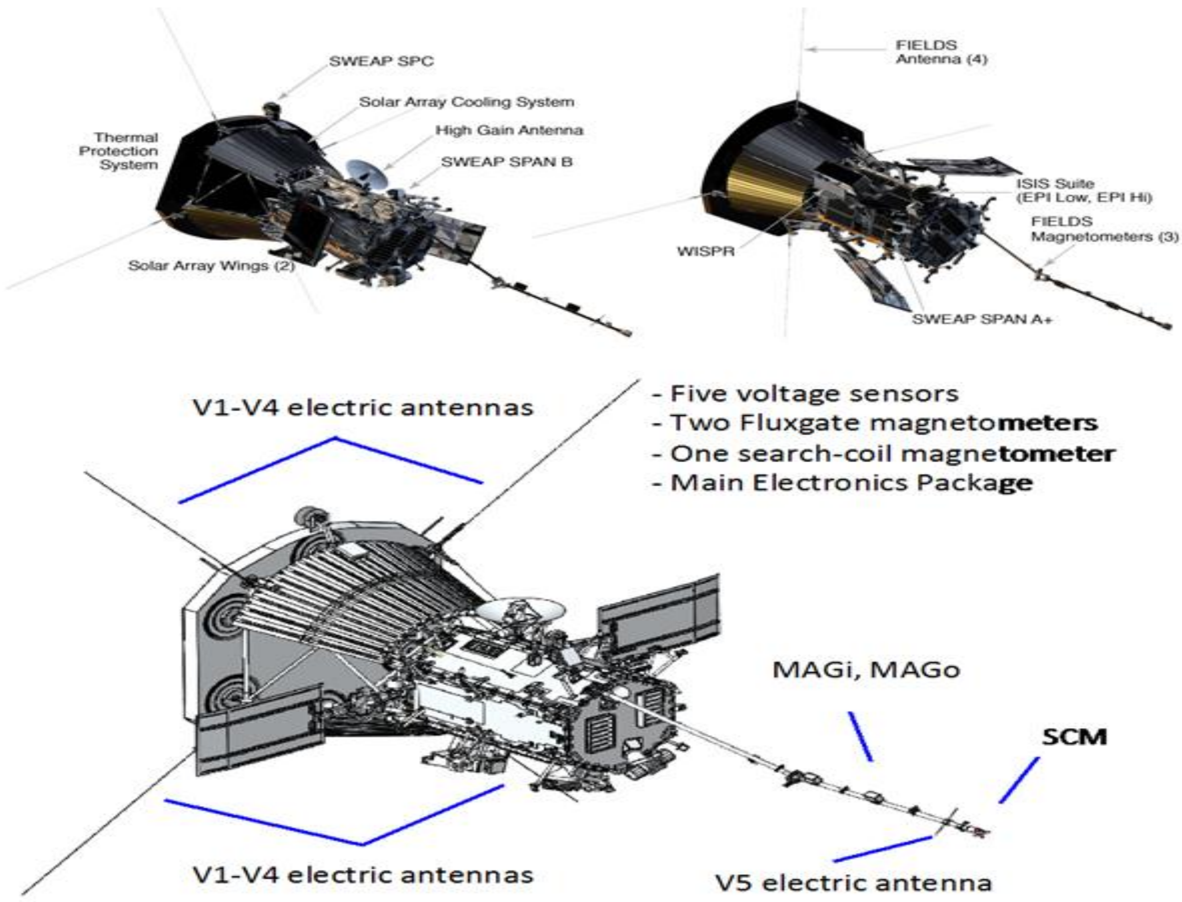


Fig. 3.1: Parker solar probe Spacecraft.

Parker Solar Probe Heat Shield

The eight-foot-diameter heat shield will safeguard everything within its umbra, the shadow it casts on the spacecraft. At Parker Solar Probe's closest approach to the Sun, temperatures on the heat shield will reach nearly 2,500 degrees Fahrenheit, but the spacecraft and its instruments will be kept at a relatively comfortable temperature of about 85 degrees Fahrenheit.

The heat shield is made of two panels of superheated carbon-carbon composite sandwiching a lightweight 4.5-inch-thick carbon foam core. The Sun-facing side of the heat shield is also sprayed with a specially formulated white coating to reflect as much of the Sun's energy away from the spacecraft as possible.

The heat shield itself weighs only about 160 pounds — here on Earth, the foam core is 97 percent air. Because Parker Solar Probe travels so fast — 430,000 miles per hour at its closest approach to the Sun, fast enough to travel from Philadelphia to Washington, D.C., in about one second — the shield and spacecraft have to be light to achieve the needed orbit.

The reinstallation of the Thermal Protection System — which was briefly attached to the spacecraft during testing at the Johns Hopkins Applied Physics Lab in Laurel, Maryland, in fall 2017 — marks the first time in months that Parker Solar Probe has been fully integrated. The heat shield and spacecraft underwent testing and evaluation separately at NASA's Goddard Space Flight Center in Greenbelt, Maryland, before shipping out to Astrotech Space Operations in Titusville, Florida, in April 2018. With the recent reunification, Parker Solar Probe inches closer to launch and toward the Sun.

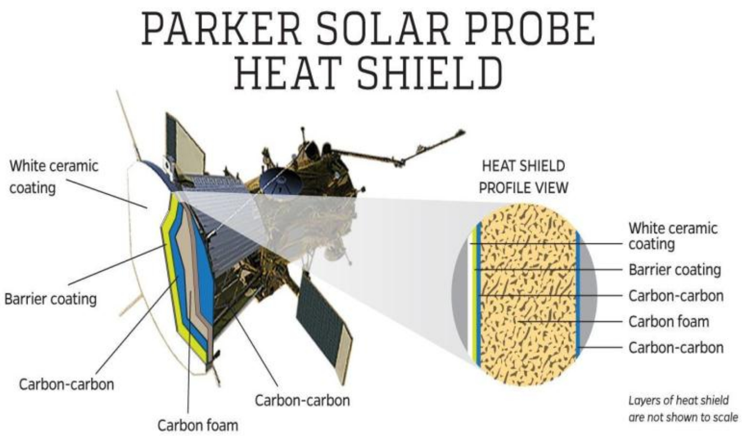


Fig. 3.1.1: Heat Shield.

Parker solar probe Instruments

Parker Solar Probe works under extreme conditions as it gathers data in the Sun's corona, grazing closer to our star than any spacecraft before. Its four instrument suites characterize the dynamic region close to the Sun by measuring particles and electric and magnetic fields, and each was specially designed to withstand the harsh radiation and temperatures they will encounter.

Fields

Surveyor of the invisible forces, the FIELDS instrument suite captures the scale and shape of electric and magnetic fields in the Sun's atmosphere. FIELDS measures waves and turbulence in the inner heliosphere with high time resolution to understand the fields associated with waves, shocks and magnetic reconnection, a process by which magnetic field lines explosively realign.

FIELDS was designed, built, and is operated by a team lead by the Space Sciences Laboratory at the University of California, Berkeley (principal investigator Stuart D. Bale).

Wisper

The Wide-Field Imager for Parker Solar Probe is the only imaging instrument aboard the spacecraft. WISPR looks at the large-scale structure of the corona and solar wind before the spacecraft flies through it. About the size of a shoebox, WISPR takes images from afar of structures like coronal mass ejections, or CMEs, jets and other ejecta from the Sun. These structures travel out from the Sun and eventually overtake the spacecraft, where the spacecraft's other instruments take in-situ measurements. WISPR helps link what's happening in the large-scale coronal structure to the detailed physical measurements being captured directly in the near-Sun environment.

WISPR was designed and developed by the Solar and Heliophysics Physics Branch at the Naval Research Laboratory in Washington, D.C. (principal investigator Russell Howard), which will also develop the observing program.

Sweap

The Solar Wind Electrons Alphas and Protons investigation, or SWEAP, gathers observations using two complementary instruments: the Solar Probe Cup, or SPC, and the Solar Probe Analyzers, or SPAN. The instruments count the most abundant particles in the solar wind —

electrons, protons and helium ions — and measure such properties as velocity, density, and temperature to improve our understanding of the solar wind and coronal plasma.

SWEAP was built mainly at the Smithsonian Astrophysical Observatory in Cambridge, Massachusetts, and at the Space Sciences Laboratory at the University of California, Berkeley. The institutions jointly operate the instrument. The principal investigator is Justin Kasper from the University of Michigan.

Isois

The Integrated Science Investigation of the Sun — ISOIS, pronounced "ee-sis" and including the symbol for the Sun in its acronym — uses two complementary instruments in one combined scientific investigation to measure particles across a wide range of energies. By measuring electrons, protons and ions, ISOIS will understand the particles' lifecycles — where they came from, how they became accelerated and how they move out from the Sun through interplanetary space. The two energetic particle instruments on ISOIS are called EPI-Lo and EPI-Hi (EPI stands for Energetic Particle Instrument).

ISʘIS is led by Princeton University in Princeton, New Jersey (principal investigator David McComas), and was built largely at the Johns Hopkins Applied Physics Laboratory in Laurel, Maryland, and Caltech, in Pasadena, California, with significant contributions from Southwest Research Institute in San Antonio, Texas, and NASA's Goddard Space Flight Center in Greenbelt, Maryland. The ISʘIS Science Operations Center is operated at the University of New Hampshire in Durham.

Fig. 3.2.1: Actual parker solar probe.

Trajectory

The Parker Solar Probe mission design uses repeated gravity assists at Venus to incrementally decrease its orbital perihelion to achieve a final altitude (above the surface) of approximately 8.5 solar radii, or about 6×10^6 km (3.7×10^6 mi; 0.040 AU). The spacecraft trajectory will include seven Venus flybys over nearly seven years to gradually shrink its elliptical orbit around the Sun, for a total of 24 orbits.[1] The near Sun radiation environment is predicted to cause spacecraft charging effects, radiation damage in materials and electronics, and communication interruptions, so the orbit will be highly elliptical with short times spent near the Sun.

The trajectory requires high launch energy, so the probe was launched on a Delta IV Heavy class launch vehicle and an upper stage based on the STAR 48BV solid rocket motor. Interplanetary gravity assists will provide further deceleration relative to its heliocentric orbit, which will result in a heliocentric speed record at perihelion. As the probe passes around the Sun, it will achieve a velocity of up to 200 km/s (120 mi/s), which will temporarily make it the fastest manmade object, almost three times as fast as the current record holder, Helios-B. Like every object in an orbit, due to gravity the spacecraft will accelerate as it nears perihelion, then slow down again afterward until it reaches its aphelion.

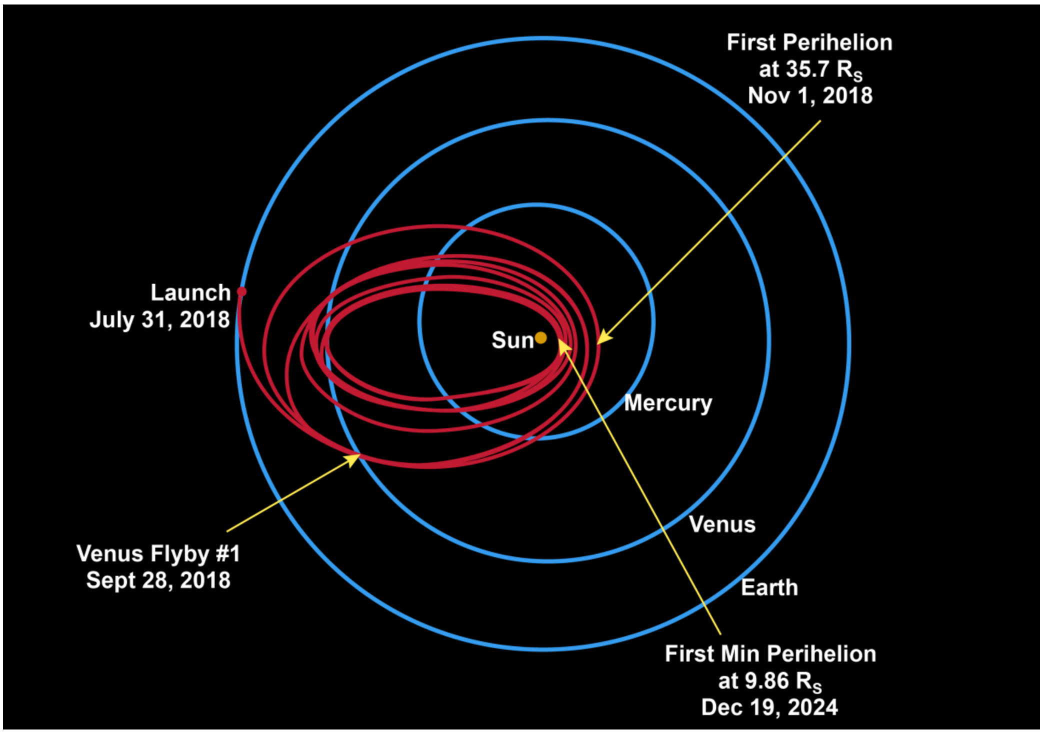


Fig. 4.1: Probe Trajectory.

Timeline

Year	Events
2015	**March:** Critical design review (CDR)
2016	**May:** System integration review. **July:** KDP-D **July:** Start of integration and testing.
2017	**Begin March 2017:** Instrument deliveries. **Begin August 2017:** Observatory system testing. **Fall 2017:** Shipment of observatory to GSFC.
2018	**Spring 2018:** Shipment of observatory to cape Canaveral. **August 12, 2018:** Launch-3.31 a.m. EDT (7:31 UTC) **October 3, 2018:** Venus Flyby #1-4:44 a.m. EDT (8:44 UTC) **November 5, 2018:** Perihelion #1-10:20 p.m. EST (Nov. 6, 2018 at 03:27 UTC)
2019	**January 19, 2019:** Aphelion#1 **January 20, 2019:** Second orbit begins. **April 4,2019:** Perihelion #2 **September 1, 2019:** Perihelion #3 **December 26, 2019:** Venus flyby #2
2020	**January 29, 2020:** Perihelion #4 **June 7, 2020:** Perihelion #5 **July 11, 2020:** Venus flyby #3

	September 27,2020: Perihelion #6
2021	**January 17,2021:** Perihelion #7 **February 20,2021**: Venus flyby#4 **April 29,2021:** Perihelion #8 **August 9, 2021:** Perihelion #9 **October 16, 2021:** Venus flyby#5 **November 21, 2021:** Perihelion #10
2022	**February 25, 2022:** Perihelion #11 **June 1,2022:** Perihelion #12 **September 6, 2022:** Perihelion #13 **December 11, 2022:** Perihelion #14
2023	**March 17, 2023:** Perihelion #15 **June 22, 2023:** Perihelion #16 **August 21, 2023:** Venus flyby#6 **September 27, 2023:** Perihelion #17 **December 29, 2023:** Perihelion #18
2024	**March 30, 2024:** Perihelion #19 **June 30, 2024:** Perihelion #20 **September 30, 2024:** Perihelion #21 **November 6, 2024:** Venus fyby#7 Final Venus flyby **December 24, 2024:** Perihelion #22 First close approach
2025	**March 22, 2025:** Perihelion #23 **June 19, 2025:** Perihelion #24

CONCLUSION

In this paper we define the development of parker solar probe, its various parts, their function and the NASA's mission to touch the sun. The Parker solar Program's storied history is vast and well documented. Understanding the design and operations of this unique and complex vehicle is not confined to the study of one program, but of many. It touches on only a handful of the lessons that were learned through the various supersonic and hypersonic research programs that laid the foundation for Parker solar probe.

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