SAMPLE

Solar System Missions: Parker Solar Probe

Touching the Sun

Aira Astralis

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This free sample contains the Introduction and Chapter 1. The complete book contains the full contents above.

Introduction

The Parker Solar Probe is the fastest, closest, and most heat-tolerant machine human beings have ever flown, and its purpose is the oldest unsolved question in solar physics: why the atmosphere wrapped around the Sun runs at millions of degrees over a surface of a bare six thousand. Launched in August 2018 on a tower of fire from Cape Canaveral, the probe repeatedly dives through the Sun's corona, the silvery crown visible in a total eclipse, closing to within a whisker of the surface, astronomically speaking, at speeds near seven hundred thousand kilometers per hour, protected by a shield of carbon foam that holds its instruments at room temperature while its front face glows like a furnace door. It is the first NASA spacecraft named for a living person, and the man it honors, the physicist Eugene Parker, predicted the solar wind the spacecraft now flies through six decades before it launched, against the published skepticism of nearly every reviewer in the field.

This book carries the whole account in language anyone can read. The opening chapters carry the science's history: the centuries of eclipse observers who mapped the corona without understanding it, the comet tails that betrayed a wind from the Sun, and the young theoretician who, in 1958, computed that the corona cannot stay still and was told to go read the subject in a library. The middle chapters carry the physics: what the corona is made of, why it burns, what the solar wind is, how it blows the bubble the planets live in, and how it treats the worlds in its path.

The later chapters carry the machine: the sixty-year struggle to fund and fly a probe to the Sun, the orbit that uses Venus seven times as a brake, the heat shield and the instruments that peek around it, and the discoveries that have already rewritten the textbooks, from the magnetic switchbacks that pepper the young wind to the crossing, in April 2021, of the boundary where the corona ends and flying becomes possible.

The account is careful with numbers, honest about what remains unknown, and generous with the human story, because this mission has one of the great casts in the history of spaceflight: a stubborn theoretician, a comet-tail expert, an agency that cancelled the dream twice, and an engineering team that built a spaceship to swim in fire.

A word on the corona's component brightnesses, because the distinctions structure every later chapter. The white crown seen at eclipse is mostly the K-corona, photospheric sunlight scattered off the corona's free electrons, its spectrum smoothed to a continuum by the Doppler shifts of the scattering electrons; the F-corona is the same sunlight scattered off interplanetary dust,

and it carries the Fraunhofer absorption lines of the photosphere unchanged, betraying its borrowed light; and the E-corona is the corona's own faint emission, the spectral lines of the hot ions themselves, the lines that carried the million-degree secret. The three brightnesses interleave, and the K-corona dominates near the Sun while the F-corona takes over farther out, the dust's glow persisting into the zodiacal light of the night sky, so that the visual boundary of the corona is partly a matter of which scattering is winning, a subtlety the eclipse photographers of the nineteenth century were the first to notice and the last to explain.

The corona's light is also an engineering problem that shaped this mission, and the chapter should state it plainly. The Sun's disk is a million times brighter than the crown at its brightest and a hundred million times brighter than the faint structures the solar physicists most want, so any instrument studying the corona must create an artificial eclipse, and the coronagraph, invented by Bernard Lyot in the 1930s, does exactly that, an occulting disk in a telescope that hides the photosphere and shows the crown. Every coronagraph fights the same enemy, stray light diffracting around its disk, and the deeper the observation tries to reach toward the Sun's limb, the worse the fight becomes; the answer, eventually, was to leave the telescope altogether, because a spacecraft inside the corona needs no artificial eclipse, the disk being conveniently occluded by the shield of the probe itself.

The mission's camera chapter returns to this: the Parker Solar Probe is, among other things, a coronagraph with a heat shield, the eclipse made real, flown from inside the crown it photographs.

The corona's naming deserves a line, because the word's ordinariness hides a history. Corona is Latin for crown, the aura's name from the eclipse observers, and the related term for the crown's shape at minimum, the coronal belt, and at maximum, the full crown, entered the field's working vocabulary from the nineteenth-century drawings; the chromosphere, the thin red layer beneath, took its name from the Greek for color, its rose glow noted at every totality; and the photosphere, the visible surface, is the light sphere, named in the 1860s when the spectral analysis proved the surface gas's nature. The vocabulary is a museum of the questions: each name records what its namers saw before they understood it, and the reader who uses the words now uses the whole history, the crown named for its shape before anyone knew it was fire, a fact worth carrying to the eclipse.

Chapter 1: The Riddle of the Crown

The corona, the Sun's outermost atmosphere, has been watched for as long as eclipses have frightened people, but its scientific history begins with the patient eclipse observers of the eighteenth century. In 1724, the French-Italian astronomer Giacomo Maraldi recognized that the pale aura visible during a solar eclipse was a genuine feature attached to the Sun rather than an artifact of the Moon's atmosphere or the eye's dazzle, and through the following century the crown was drawn, catalogued, and argued over at every total eclipse, its shape waxing and waning with the sunspot cycle in a correlation nobody could explain because nobody yet knew the Sun had a magnetic cycle.

The nineteenth century added the strangest facts. Eclipse spectroscopy, applying the new art of reading light's chemistry, found that the corona's spectrum carried lines belonging to no known element, and English astronomer Norman Lockyer, who had already found helium, named the suspected new element coronium; the idea that the crown was made of unknown matter hung on for decades. The truth, established by Walter Grotrian in 1939 and Bengt Edlen in the early forties, was stranger than the fiction: the coronal lines were ordinary iron, but iron stripped of a dozen or more of its electrons, a condition that requires a surrounding gas at temperatures of a million degrees and more. The crown, in other words, was not merely bright and mysterious; it was hotter than anything else in the solar system's neighborhood, a hundred times hotter than the visible surface it floated above.

The riddle this posed deserves its plain statement, because the entire mission of this book exists to attack it. The Sun's energy is made deep in its core and released at the surface, the photosphere, at about six thousand degrees; moving outward from the surface, the temperature first falls a little, through the narrow chromosphere, and then climbs, violently, through a boundary a few thousand kilometers up, until the corona above runs at one to two million degrees, and in solar flares twenty million. A fire cannot heat a room above its own fireplace; a body of gas cannot, by any everyday logic, get thousands of times hotter than the floor it rests on.

The answer, understood in outline for generations, is magnetic: the corona is heated by the Sun's magnetic field, which threads the atmosphere, stores energy in its tangles, and releases it high above the surface, and the entire science of coronal heating is the effort to find the exact mechanisms by which magnetic energy becomes coronal heat. The corona's faintness is the other half of the riddle: the gas is so hot and so tenuous that it barely glows in visible light, a hundred-millionth of the disk's brightness, which is why the

crown can be studied directly only during an eclipse, from high mountain observatories, or from spacecraft, and why the earliest solar probes were eclipse-chasers by proxy.

The chapter closes where the history closed: by the middle of the twentieth century, the corona was known to be hot, magnetized, faint, and structured, its streamers and holes mapped by generations of eclipse photographers, and the question of its heating had become the central problem of solar physics, awaiting the man and the machine the following chapters introduce.

The Carrington event gets a paragraph to itself, because it still serves as the benchmark the whole space-weather enterprise is built against. On the first of September 1859, Carrington, a wealthy English amateur of great skill, watched and drew an enormous white-light flare crossing a sunspot group; within a day the Earth's magnetic field was convulsed, auroras seen nearly to the tropics, telegraph systems shocking their operators, papers in the machines reportedly catching fire where the induced currents ran strongest. The connection

Carrington suspected, that something had crossed the space from Sun to Earth carrying the disturbance, was a guess decades ahead of its evidence, and the modern reconstruction of the event, a coronal mass ejection arriving unusually fast, running into wind the Sun had already strengthened, gives the field its worst case: the same event today would be measured in satellites lost, grids tripped, and a technological bill in the trillions, the reason the storms chapter of this book keeps returning to the Sun's routine tantrums as a civilizational problem rather than a curiosity.

The interwar years also carried the auroral physics that Birkeland's experiments began, and the thread belongs to the chapter's honest record. Birkeland's terrella, a magnetized metal sphere bombarded by cathode rays in a vacuum chamber, produced rings of glow around its poles that he identified, correctly, as the auroras' mechanism, charged particles from the Sun guided by the Earth's field into the polar air; the mathematical community of the day preferred Chapman's mathematically elegant alternatives, and the dispute, pursued with a bitterness the histories record, was settled decades later by spacecraft in Birkeland's favor. The reader should keep the pattern in view: every element of the wind story, the particles, the field, the connection, was proposed early, resisted long, and confirmed finally, and the resistance was never foolishness but the ordinary conservatism of a science being asked to believe a lot at once.

Chapman's static corona deserves its technical paragraph, because the two rivals' mathematics is the story's engine. Chapman calculated that a gas at a million degrees conducts heat extraordinarily well, so well that the corona's

heat must flow outward into space along an atmosphere that thins with altitude, and he found a solution in which the hot gas simply extends, thinning all the way out to the Earth's distance and beyond, a static halo in pressure balance with the interstellar medium. The solution was mathematically sound and physically doomed, and the flaw Parker found was in the boundary condition: far from the Sun, Chapman's atmosphere must match the interstellar pressure, but the million-degree gas at the corona carries so much pressure at great distances that no interstellar medium can hold it, and the only consistent solution is expansion.

The episode is the textbook demonstration that in fluid dynamics the boundary conditions are half the physics, and the two men's papers, read together, remain among the best exercises a student of astrophysics can be given.

The confirmation's instruments deserve their closing note, because the wind's first detections were themselves an engineering story. Gringauz's detectors, simple plasma traps on the Soviet Luna probes, registered the ion flow at the

Moon's distance in 1959, and the American measurements followed; Mariner 2's crossing of interplanetary space in 1962, with a plasma instrument running continuously, removed the last doubt, reporting the wind's speed, density, and structure for months. Within four years of Parker's paper, the argument was over; within a decade, the wind was a working environment, the subject of spacecraft design rather than speculation; and the young heretic of 1958 became the field's senior statesman while still in his thirties, a speed of vindication the history of science has rarely managed, and the reason this book's middle chapters can describe the wind's physics as settled rather than argued.

End of free sample. The full book is available at putrabooks.github.io

ABOUT THE AUTHOR

Aira Astralis is a science writer specializing in astronomy and space exploration. Her work spans the full breadth of humanity's relationship with the cosmos -- from the earliest naked-eye observations to the engineering marvels of modern space missions.

Her books are built on a foundation of primary sources: peer-reviewed research, mission archives, and direct engagement with the scientific community. She writes for readers who want to understand not just what we know about the universe, but how we came to know it.

She believes that the most important frontier is not out there but in the gap between what scientists discover and what the public understands. Her books exist to close that gap.