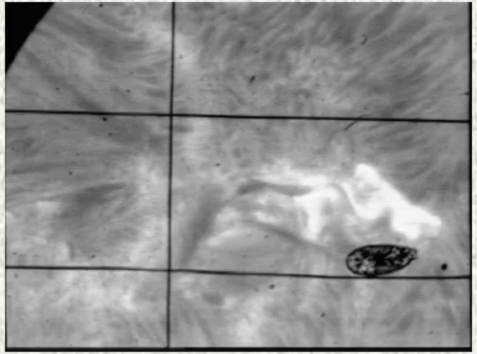
My reality

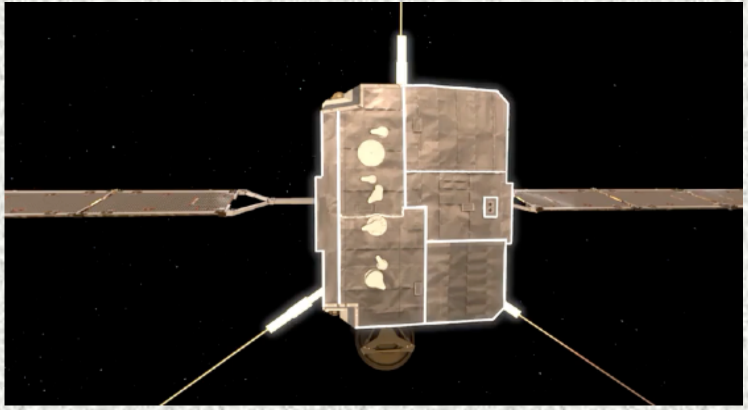


Radiative transfer of Mg I (solar-like stars)

Radiative transfer + magnetic field: Spectropolarimetry of Sun’s chromosphere

Career:

- Hydrosimulations of coronal loops in transition region
- Polarimetry of corona and UV imaging/CMEs/Space Weather



Dream: Unveiling the Solar Magnetic Field

The dream mission should address a critical question in solar physics:

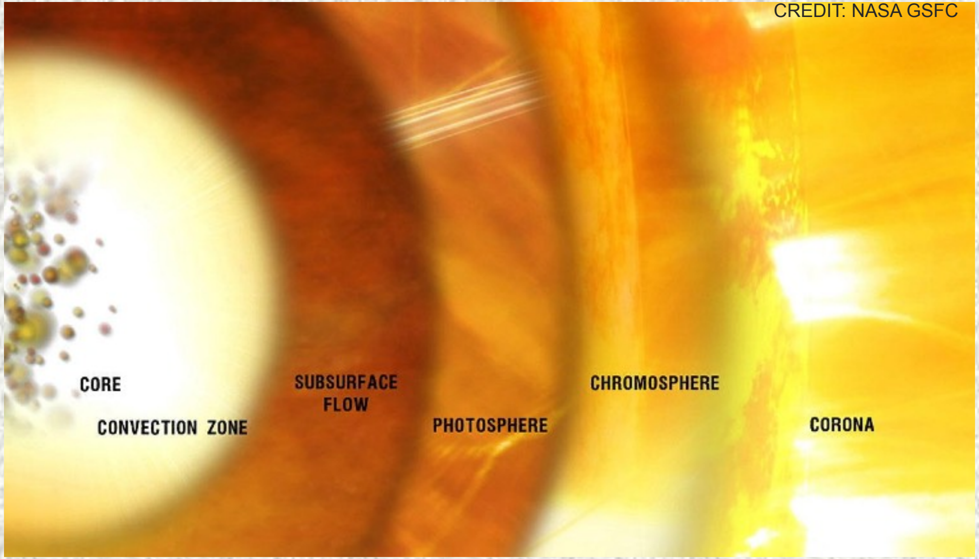
"How does the magnetic field of the solar upper atmosphere, from the chromosphere and upward into the corona, control the dynamics and the energy build-up of the spectacular phenomena we observe in our nearest star?"

Goals:

to achieve a breakthrough by providing **continuous measurements of the magnetic field in the solar corona** through ultraviolet (UV - 121.6 nm) imaging polarimetry and spectroscopy.

to measure the magnetic field from the photosphere to the upper chromosphere through near-UV disk spectropolarimeter.

→ to **unveil the magnetic coupling of the photosphere and the chromosphere with the corona**.



CREDIT: NASA GSFC

Scientific Questions and Goals

New measurements will enable scientists to address key overarching questions:

Magnetic Energy Storage and Release: What are the physical processes underlying magnetic energy storage and subsequent release in eruption precursors such as coronal cavities and filament channels?

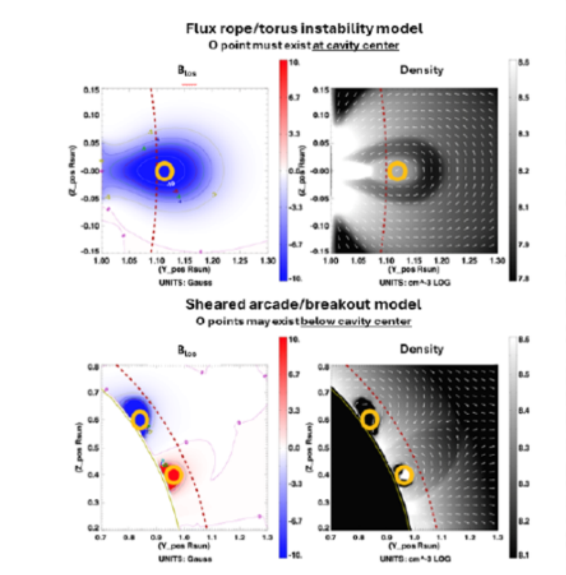
Energy Transfer and Solar Wind: What are the physical processes underlying energy transfer from the magnetic field to plasma at the base of the solar wind?

Atmospheric coupling: How does the magnetic field couple the different layers of the atmosphere, and how does it transport energy from the photosphere to the corona?

The mission should aim to:

Study **magnetic field configurations** responsible for energy buildup and release in solar eruptions, emphasizing discrimination between different eruption models.

Diagnose **solar wind temperature anisotropies** at closed-open field boundaries to constrain models of coronal heating and solar wind acceleration.

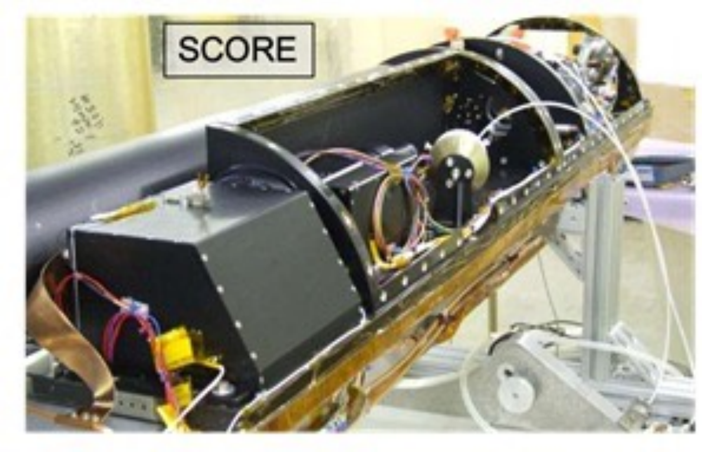


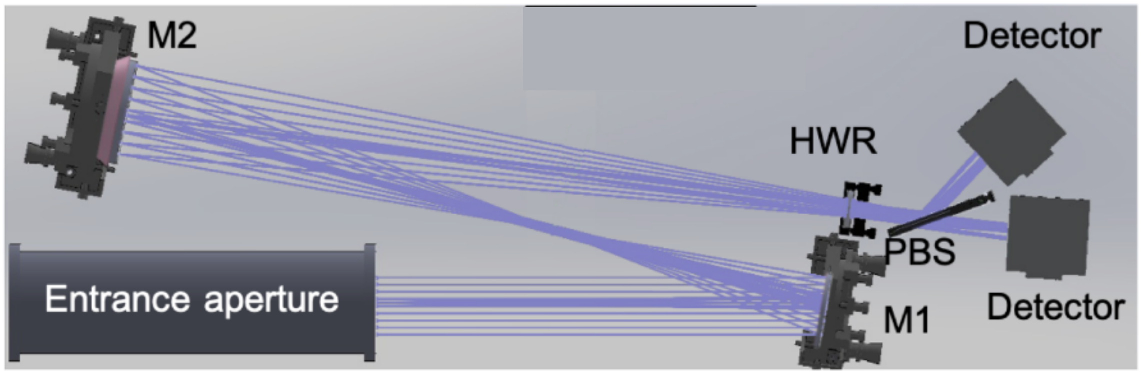
H I Lyman-α Coronagraph and Polarimeter

Measurement: Linear polarization of the resonantly-scattered component of the **H I Lyman-α line (121.6 nm)**.
Heritage: based on the INAF-developed **SCORE (Sounding-rocket Coronagraph Experiment)**, which flew in 2009. SCORE was also the proof-of-concept for the **Metis coronagraph** on **Solar Orbiter**.

A neutral density filter on the instrument's door. When the door is closed, the telescope will be able to observe the chromospheric Lyman-α emission from the solar disk.

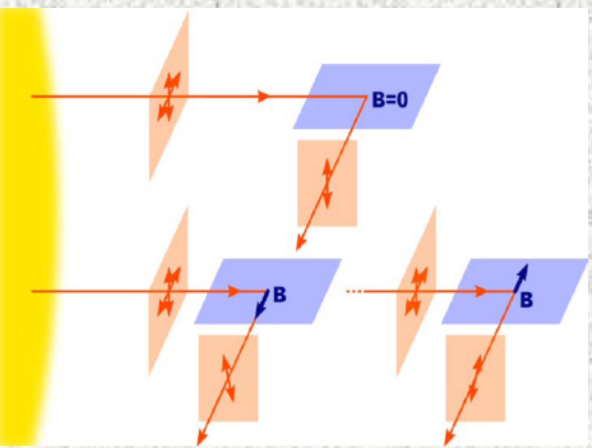
This instrument could have the possibility to do also spectroscopy in the Lyman-α.





The coronagraph offers the possibility of **observing coronal regions near the limb** where the coronal magnetic field, **via the Hanle effect**, modifies the polarization state of the resonantly scattered H I Lyman-α line-emission.

Hanle effect



Schematic representation of the Hanle effect (adapted from Trujillo Bueno et al. 2005)

T Anisotropy

Furthermore, as **UVCS on SOHO** has shown, processes that heat and accelerate the plasma in the middle corona introduce an **anisotropy in the kinetic temperatures** of the plasma, including neutral H, in perpendicular and parallel directions to the magnetic field. This anisotropy, in turn, ess, resulting in an additional measurable effect on the linear polarization of the H I Lyman-α line. minantly non-radial solar wind is present (i.e., in the hole-streamer interfaces at heights where the solar wind picks up speed), providing insight into how the magnetic field deposits the energy in the plasma and accelerates the wind.

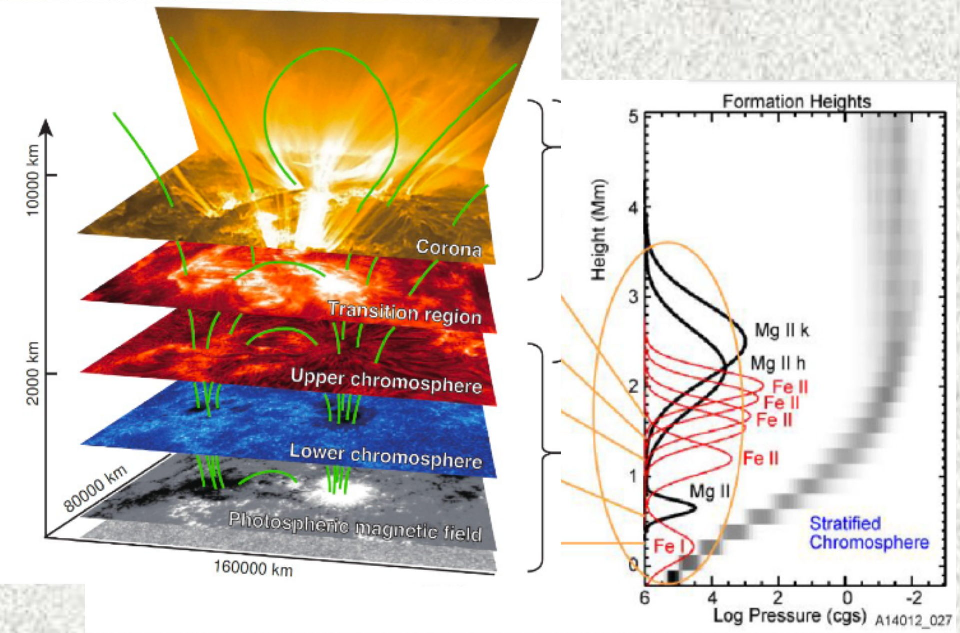
Solar Chromosphere and Upper Photosphere Spectropolarimeter

Purpose: To provide accurate measurements of **photospheric and chromospheric magnetic fields**.

Science Question: "How does the magnetic field couple the different layers of the atmosphere, and how does it transport energy from the photosphere to the corona?”

Measurement: It measures **Zeeman-induced circular polarization** and **scattering-induced linear polarization** in the near-UV spectral window of the **Mg II h and k lines** (≈279.45 nm and 280.35 nm).

Heritage: based on the Chromospheric LAyer SpectroPolarimeter, which flew on sounding rocket experiments in 2019 (CLASP2) and 2021 (CLASP2.1). CLASP2/2.1 provided high-precision full-Stokes data of Mg II h and k and nearby lines.



The mission should conduct a set of observational programs that leverage the unique capabilities of both instruments to maximize the scientific return: Active regions at the limb, Coronal cavities and prominences, flux ropes

ESA PROBA-3 Mission: A Successful Precedent

This dream mission needs to observe the corona very close to the limb to measure the magnetic field → The mission profile can directly **leverage the successful ESA PROBA-3 formation-flying technological demonstrator,** creating an **artificial eclipse** using **two Earth-orbiting satellites in formation flying**.

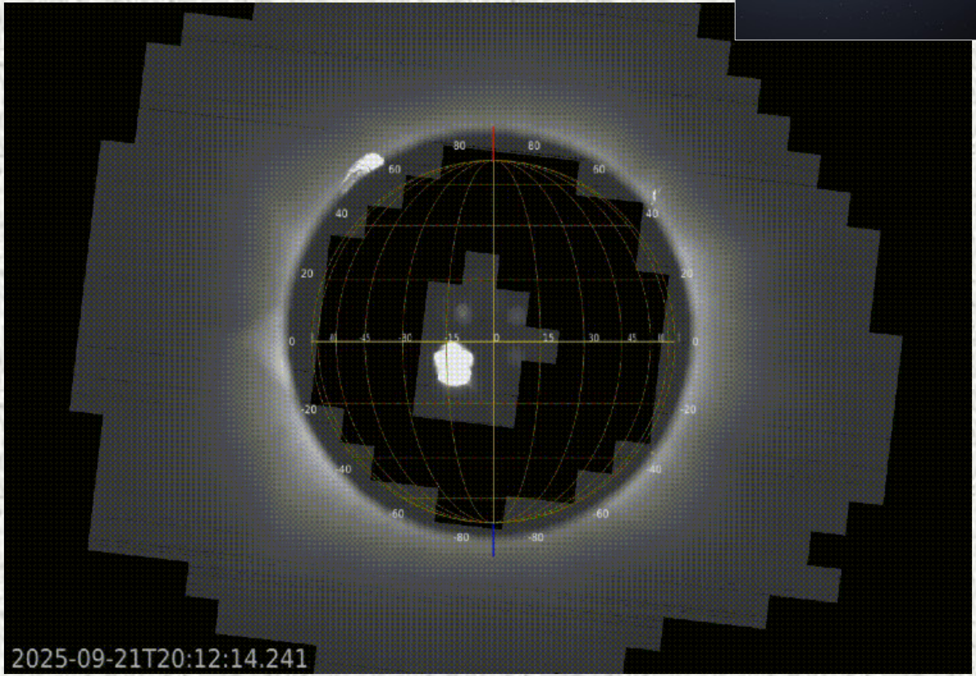
Feature	Detail
Technology	First precision formation flying mission; demonstrated two spacecraft, the Occulting Spacecraft (OSC) and coronagraph Spacecraft (CSC) flying 150 m apart in perfect formation for hours.
Milestone	Achieved the **first-artificial-eclipse images** of the visible-light K-corona with the **ASPIICS coronagraph** in March 2025.
Results	Captured the **Sun's inner corona** in multiple spectral lines (e.g., coronal green line, He D_3 line) and polarized WL. Observations are comparable to those during natural eclipses.
Key Advantage	Can create an artificial eclipse once per orbit (~19.6 h period), lasting for up to **6 hours**. Natural total eclipses only last a few minutes.

Proba-3 achieves precise formation flying (7 May 2025)

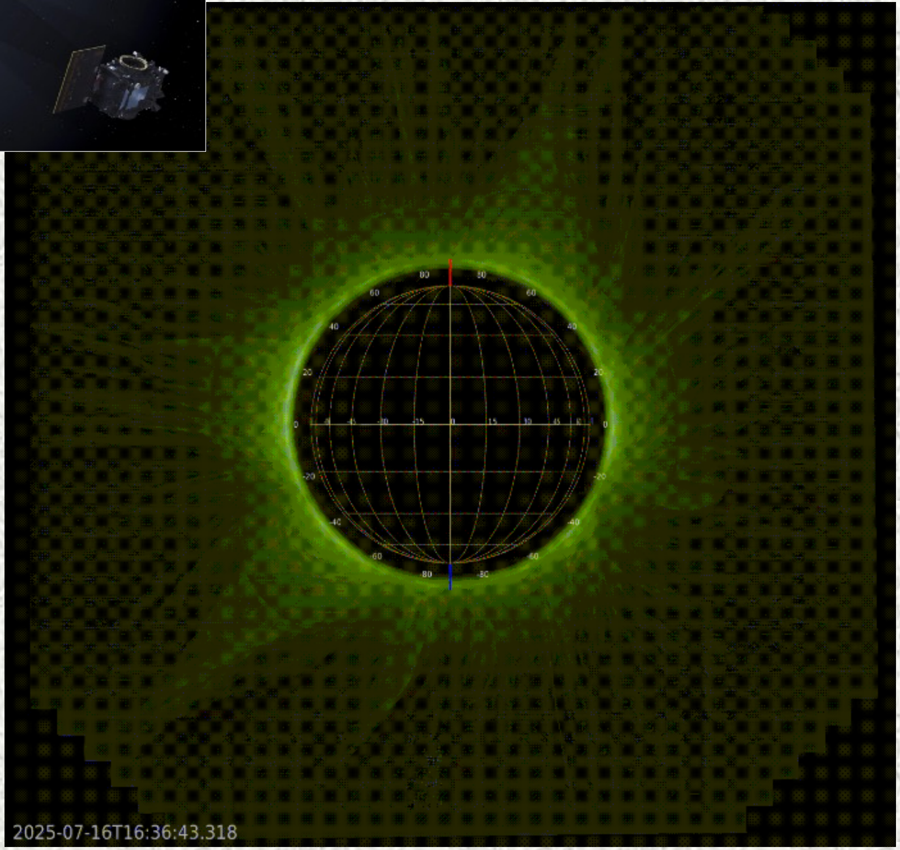
PROBA-3 has demonstrated the formation-flying capability

Formation flying, thanks to the simplification of the coronagraph design by removing components like the internal occulter, allows to reduce instrumental effects such as diffraction

ASPIICS He D_3 line



ASPIICS broad-band WL



DARKSUN

Submitted in response to ESA's call for an F-class mission opportunity 2025 → Passed Step 1 proposal as an M-class mission

Lead Proposers:

Clementina Sasso
Silvano Fineschi

INAF and DarkSun consortium

Conclusions

DarkSun is a timely mission, building on the mature **PROBA-3, SCORE** and **CLASPs** heritage, to provide the long-awaited **direct measurements of the coronal magnetic field** through UV H I Lyman-α polarimetry and **coupling with the overall atmospheric magnetic field**.
It promises to deliver essential, currently unobserved quantities necessary for understanding the Sun's dynamic evolution, solar eruptions, and solar wind acceleration.

This will also provide synergies with space weather operational mission such as ESA VIGIL and its successors.

Understanding the behaviour of the Sun's magnetic field it is essential to predict space weather effects at Earth and other planets in anticipation of the impending human space exploration.