



Europlanet Science Congress 2021
Virtual meeting
13-24 September 2021



Observing comets with the Metis coronagraph on-board the Solar Orbiter mission

V. Da Deppo^{*1}, G. Nisticò², S. Giordano³, K. Battams⁴, B. Gallagher⁴, P. Chioetto^{1,5} and the Metis "Comets and other Solar System Bodies" Topical Team (A. Bemporad³, B. Benjamin⁶, P. Cambianica⁷, C. Casini^{1,5}, A. Jody Corso¹, G. Cremonese⁷, F. Frassetto¹, S. Habbal⁶, S. Ivanovski⁸, G. Jones⁹, M. Knight¹⁰, P. Lamy¹¹, S. Mancuso³, A. Martinez¹², M. Pancrazzi³, J. Raymond¹³, C. Tubiana¹⁴, M. Uslenghi¹⁵, C. Verbeeck¹², J.-C. Vial¹⁶, G. Zimbardo², D. Spadaro¹⁷, M. Stangalini¹⁸, M. Romoli¹⁹)

¹CNR-IFN Padova, Padova, Italy; ²University of Calabria, Italy; ³INAF-OATo, Torino, Italy; ⁴US NRL, USA; ⁵CISAS, University of Padova, Padova, Italy; ⁶University of Hawaii, USA; ⁷INAF-OAPD, Padova, Italy; ⁸INAF-OATs, Trieste, Italy; ⁹UCL, London, UK; ¹⁰Dept. of Physics, U.S. Naval Academy, USA; ¹¹LATMOS, France; ¹²ROB Bruxelles, Belgium; ¹³CFA, Cambridge MA, USA; ¹⁴INAF-IAPS, Roma, Italy; ¹⁵INAF-IASF, Milano, Italy; ¹⁶IAS, Orsay, France; ¹⁷INAF-OACt, Catania, Italy; ¹⁸ASI, Roma, Italy; ¹⁹University of Florence, Florence, Italy

(*) Dr. Vania Da Deppo
CNR-IFN Padova
Via Trasea 7 - 35131 Padova - Italy
vania.dadeppo@pd.ifn.cnr.it

Solar coronagraphs and cometary science

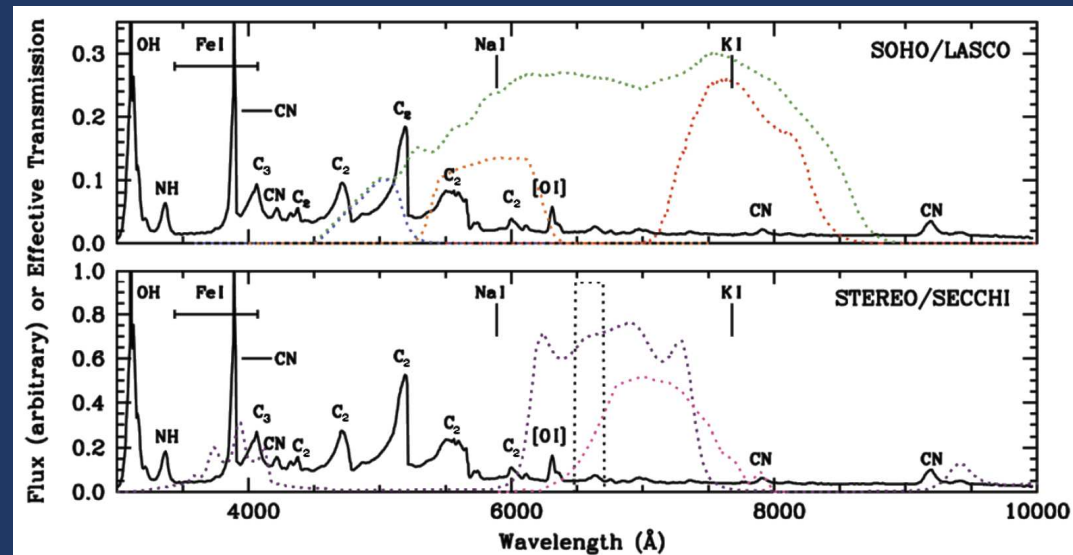
A comet passing through the solar corona provides a means to estimate the plasma parameters at each point along its path, which is a useful complement to remote sensing. In addition to the clear value for solar physics, heliophysics, and space weather application, continuous coverage of the region surrounding the Sun by a coronagraph is important for the advancement of our understanding of near-Sun comets.

A comet passing through the solar corona may change its physics and morphology, thus giving important hints for cometary science studies.

SOHO-LASCO C2 and C3 have discovered 4250 Sun-grazing and near-Sun comets.

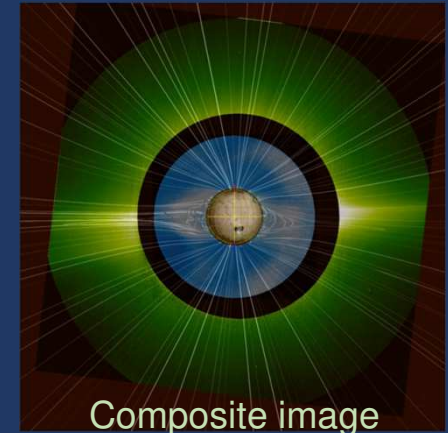
STEREO-SECCHI has also discovered 120 comets.

SOHO-UVCS had the chance to study about 20 comets in the UV [2].



SOHO/LASCO and STEREO/SECCHI bandpasses compared with a comet standard spectrum ([1])

Metis coronagraph and comets observation

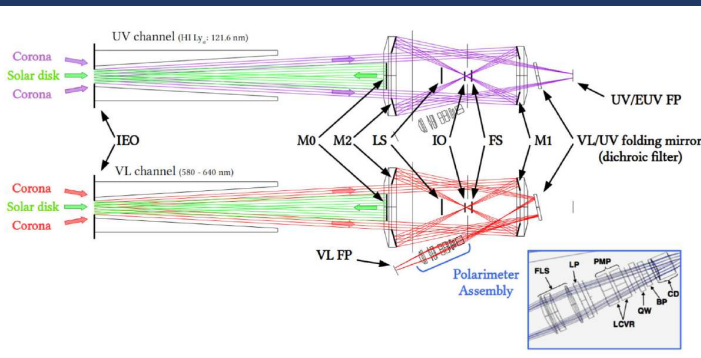


Composite image

(Credits: ESA/Solar Orbiter/Metis Team, Mauna Loa Solar Observatory/HAO/NCAR/NSF, Predictive Science Inc./NASA/NSF/AFOSR, NASA/SDO/AIA)



In November 2021 Solar Orbiter scientific phase will start. The Metis coronagraph on-board the Solar Orbiter ESA mission is devoted to solar corona observation [3]. Metis Field of View (FoV) covers an annulus between 1.6° and about 3° centered in the Sun direction [4].



The Metis instrument is conceived to perform **simultaneous imaging** of the solar corona from a near-Sun orbit in the UV narrow band **H α Lyman- α at 121.6 nm**, and in the **polarized broad-band visible light (580 – 640 nm)**.

Metis layout. On the top: the UV path. On the bottom: the VL path [4]

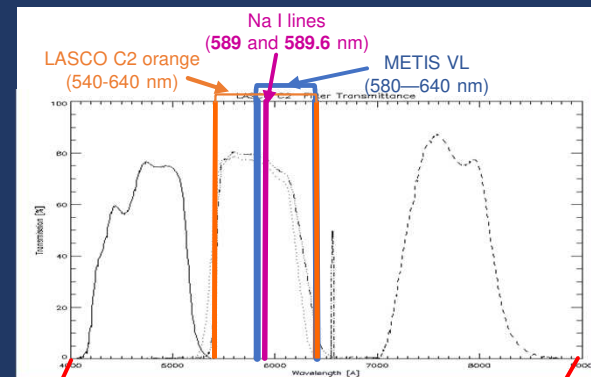
Metis will have the chance to observe near-Sun comets.

Comets with known trajectories passing in the Metis FoV will be planned to be observed; the rest, likely the majority of the comets, will be observed by serendipity.



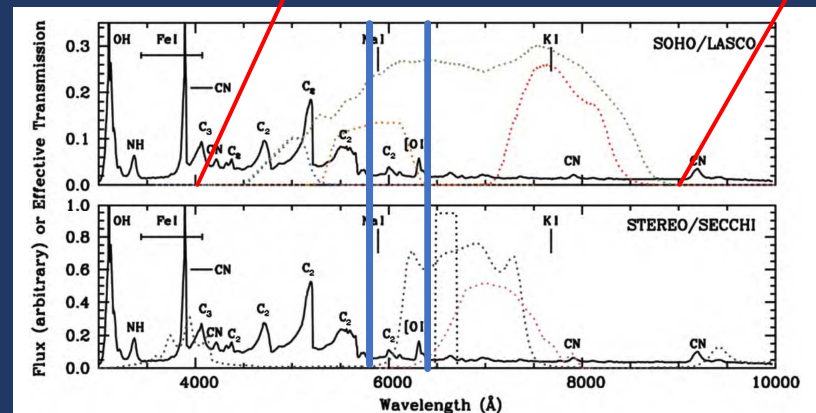
Planning for observing comets with Metis

Metis VL bandpass includes the NaI doublet which may make near-Sun comets very bright and also strong Lyman- α emissions are expected to be observed in comets [5].



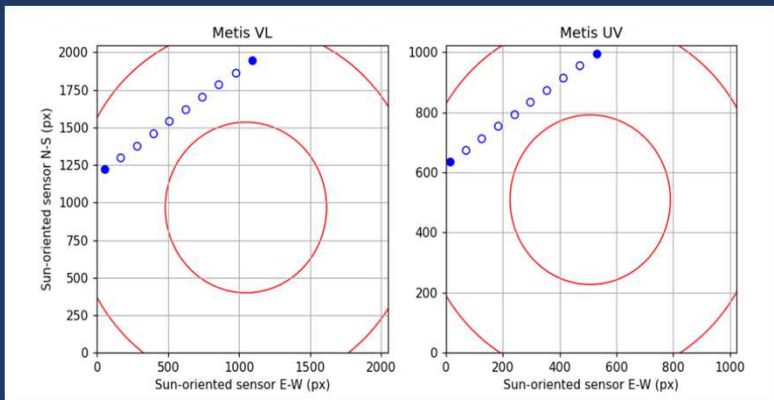
Metis observations of comets will allow to:

- study scattering, side distribution, and quantity of dust, using VL observations near comet perihelion;
- infer solar wind direction, speed and density with HI Lyman- α observations;
- analyze comet tail direction and its dynamics [6].



Metis visible light bandpass compared with LASCO and SECCHI

Expected transit of the comet C/2021 A1 (Leonard) in the Metis FoV for both VL and UV channels



A tool to calculate the "transit" of the known comets in the FoV of Metis is being devised, it will allow to predict the passage and manage the observation planning.

Conclusions



Observation campaigns are “foreseen” and will be devoted to study some of the possible comets passing inside the Metis FoV.

Some other comets will be imaged “by chance” during the nominal observation foreseen.

“Foreseen” and “by chance” comet observations can give insights to probe the near environment of the Sun and help in studying the physics and processes occurring in the tail and nucleus of the comet itself.

For the first time and of extreme importance, with the Metis coronagraph comets are going to be observed simultaneously in visible range, with the possibility of polarization imaging, and in the UV (Lyman- α).



Acknowledgment and references

Solar Orbiter is a space mission of international collaboration between ESA and NASA, operated by ESA. Metis was built and operated with funding from the Italian Space Agency (ASI), under contracts to the National Institute of Astrophysics (INAF) and industrial partners. Metis was built with hardware contributions from Germany (Bundesministerium für Wirtschaft und Energie through DLR), from the Czech Republic (PRODEX) and from ESA.

- 1- Jones, G.H. et al., "The Science of Sungrazers, Sunskirters, and Other Near-Sun Comets", *Space Sci Rev* 214(20) (2018).
- 2- Bemporad, A. et al., "A review of SOHO/UVCS observations of sungrazing comets", *Planetary and Space Science* 55(9), 1021-1030 (2007).
- 3- Antonucci, E. et al., "Metis: the Solar Orbiter visible light and ultraviolet coronal imager," *A&A* **642**, A10 (2020).
- 4- Fineschi, S. et al., "Optical design of the multi-wavelength imaging coronagraph Metis for the solar orbiter mission," *Exp. Astron.* **49**, 239-263 (2020).
- 5- Bertaux, J. L. et al. "Interpretation of Hydrogen Lyman-Alpha Observations of Comets Bennett and Encke", *A&A* 25, 415-430 (1973)
- 6- Nisticò, G. et al., "Oscillations of cometary tails: a vortex shedding phenomenon?", *A&A*, **615**, A143 (2018).