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Search in Metis images for structures related with energetic particle events

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2nd Metis Science Meeting - Naples 2025-01-28

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About Jets and SEPs

According to [Wang et al., 2006] We need

- ▶ Open (magnetic field) lines next to closed lines
- ▶ AR next to CH

We observe them

- ▶ In EUV images
- ▶ In white light (coronagraphs)

We also observe

- ▶ Flares of C class
- ▶ Radiobursts type III
- ▶ Narrow CMEs

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For this study we used a combination of observations made by the following instruments

- ▶ SDO/AIA (EUV observations)
- ▶ SOLO/Metis (white light coronagraph)
- ▶ SOHO/LASCO (white light coronagraph)
- ▶ STEREO-A/COR2 (white light coronagraph)
- ▶ STEREO-A/SWAVES (radiobursts)

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Instrument positions relative to Sun

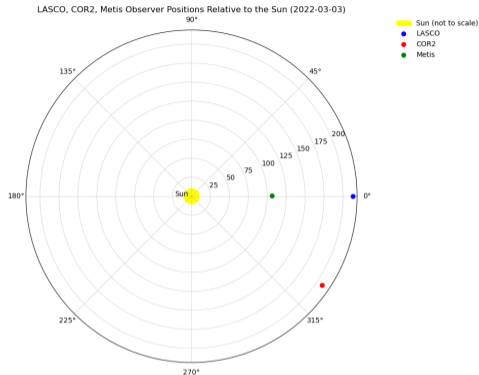


Figure: Position of SOLO/Metis, SOHO/LASCO and STEREO-A/COR2 2022-03-03

Solar Orbiter and SOHO are almost aligned, while STEREO-A is east of them

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NOAA 12957: Conditions Met-ish..

Why study the Active Region NOAA 12957?

- ▶ AR NOAA12957 observed at the center of the disk
- ▶ SOLO/SIS captured SEPs [Bučík, R. et al., 2023]
- ▶ SDO/AIA observed the formation of a jet in EUV images
- ▶ C-class flares at the AR of interest
- ▶ Radiobursts type III were detected
- ▶ Combination of open and closed magnetic lines (PFSS)

What are we missing?

Observations of white light jets. Let's use **Metis** to look for them!

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Magnetic connection with Solar Orbiter

From 2022-03-03 until 2022-03-06 Solar Orbiter was magnetically connected with Active Region NOAA 12957

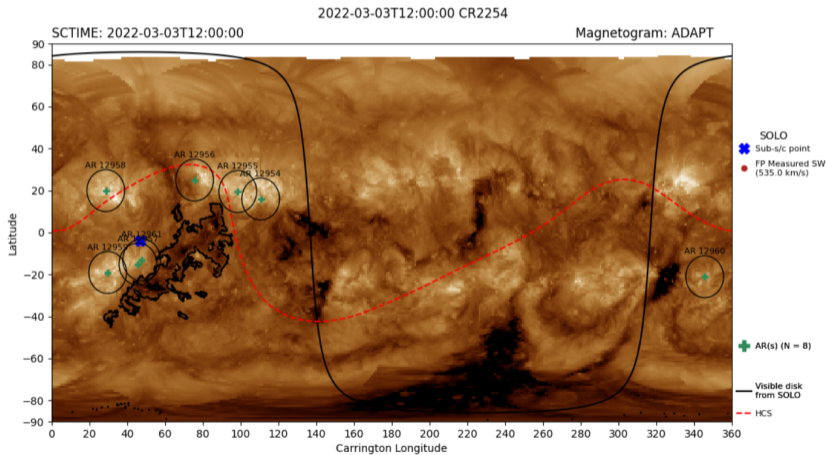


Figure: Magnetic connectivity tool

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2022-03-03: Magnetic Field Extrapolation (PFSS)

Vector Magnetic Field at 2022.03.03_14:23:55.635_TAI

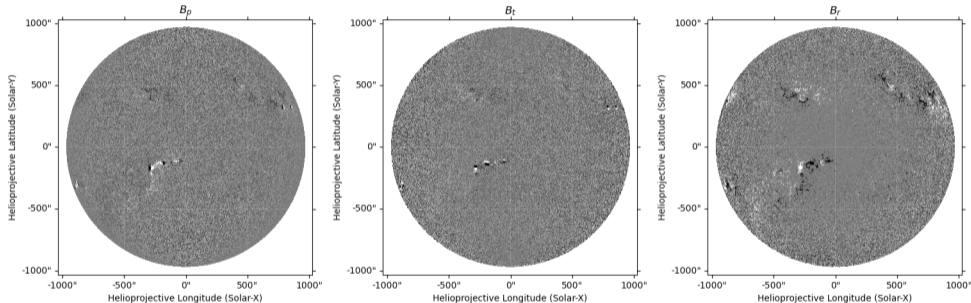


Figure: Input vector magnetogram - HMI

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2022-03-03: Magnetic Field Extrapolation (PFSS)

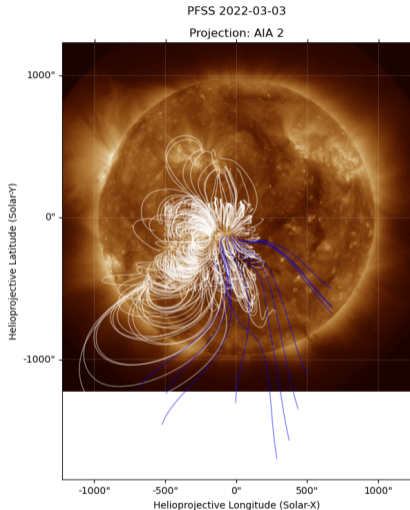


Figure: PFSS Extrapolation around NOAA 12957 (2022-03-03) [Schatten et al., 1969]

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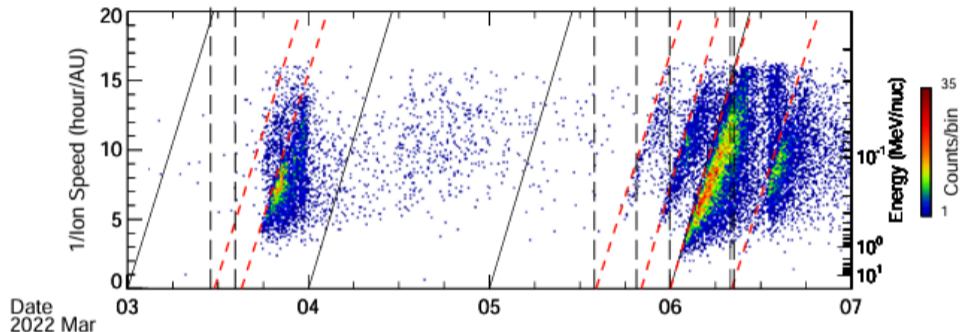


Figure: SOLO/SIS 1/ion speed vs arrival times. Red dashed lines: ion ejection. Black dashed lines: Type III radiobursts related to ion ejections. [Bučík, R. et al., 2023]

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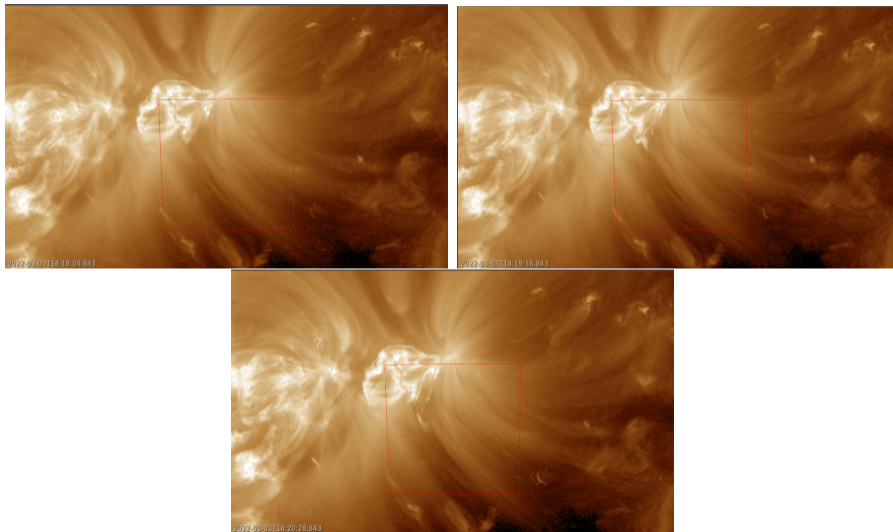


Figure: The Jet seen in SDO/AIA 193A channel (2022-03-03)

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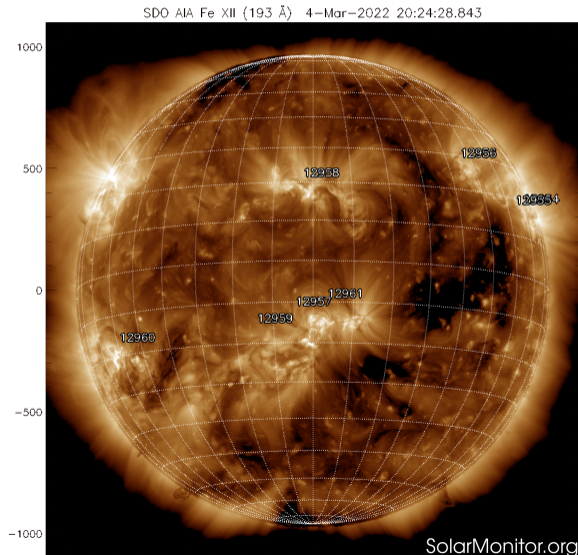
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- ▶ No significant flux of SEPs during these two days



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Events on 6 March 2022

2022-03-06 00:00 UT

- ▶ Flare of class C at AR of interest
- ▶ Strong radioburst type III
- ▶ Narrow CME (LASCO)
- ▶ No Metis observation available

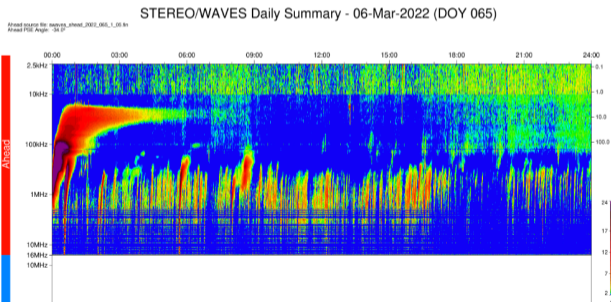


Figure: STEREO-A/SWAVES 2022-03-06

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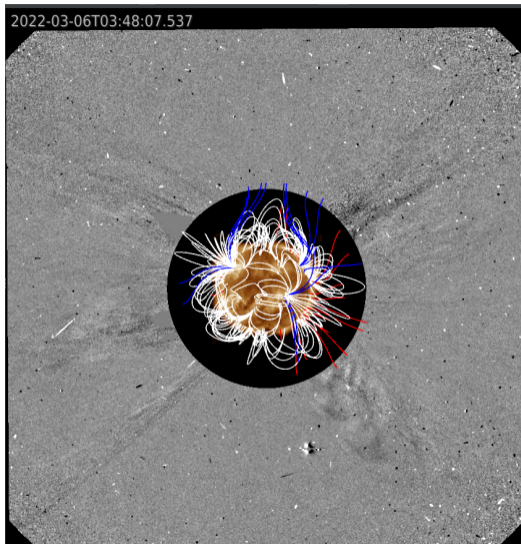


Figure: Narrow CME at SW Hemisphere - LASCO/C2

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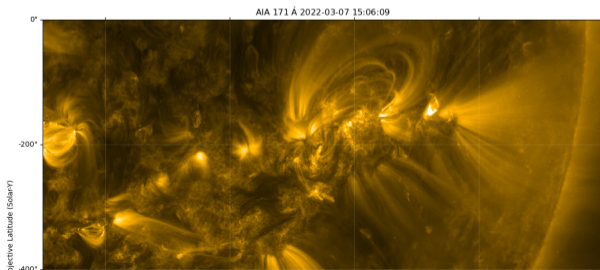
Events on 7 March 2022

Magnetic Connection between Solar Orbiter and NOAA 12957 is dropped

Indications of the presence of white light jet

- ▶ The AR of interest is close to the limb
- ▶ C class flare was observed
- ▶ Radioburst type III observed

Figure: 2022-03-07 - AIA 171Å



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STEREO/WAVES Daily Summary - 07-Mar-2022 (DOY 066)

Ahead source file: swaves_ahead_2022_066_1_05.fits
Ahead PSE Angle: -34.0°

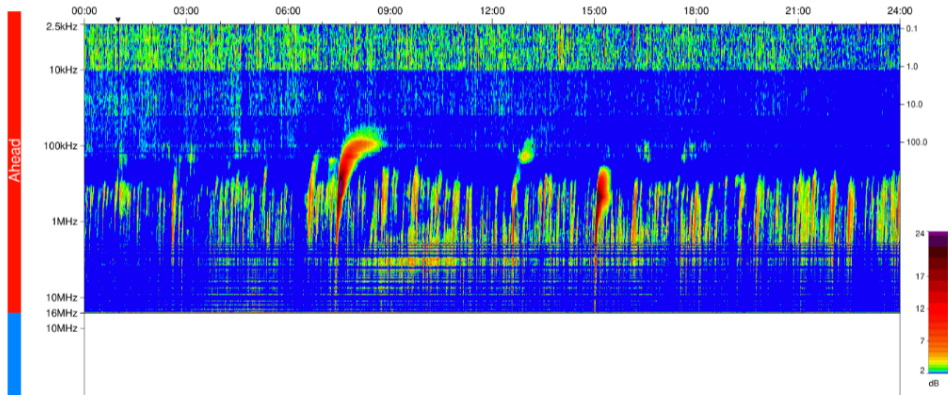


Figure: STEREO-A/WAVES 2022-03-07

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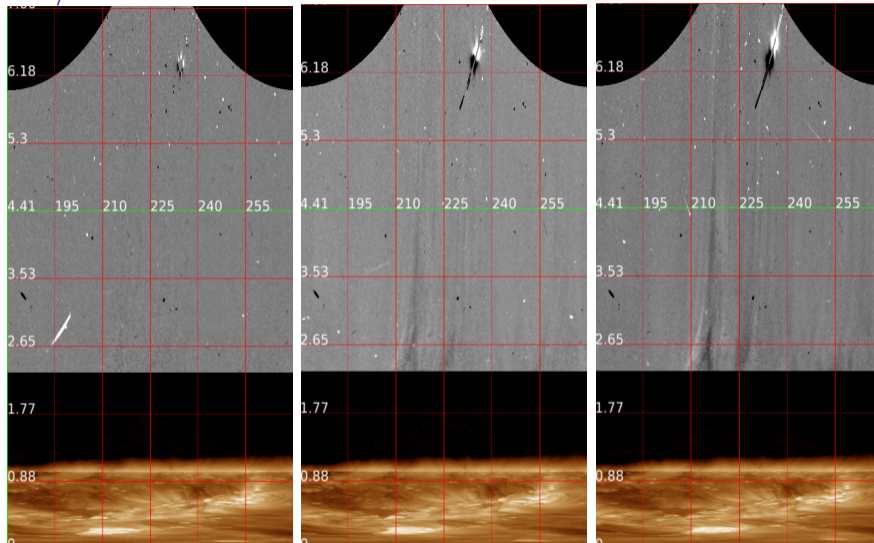


Figure: LASCO/C2 Base Difference 2022-03-07 15:30 to 18:20

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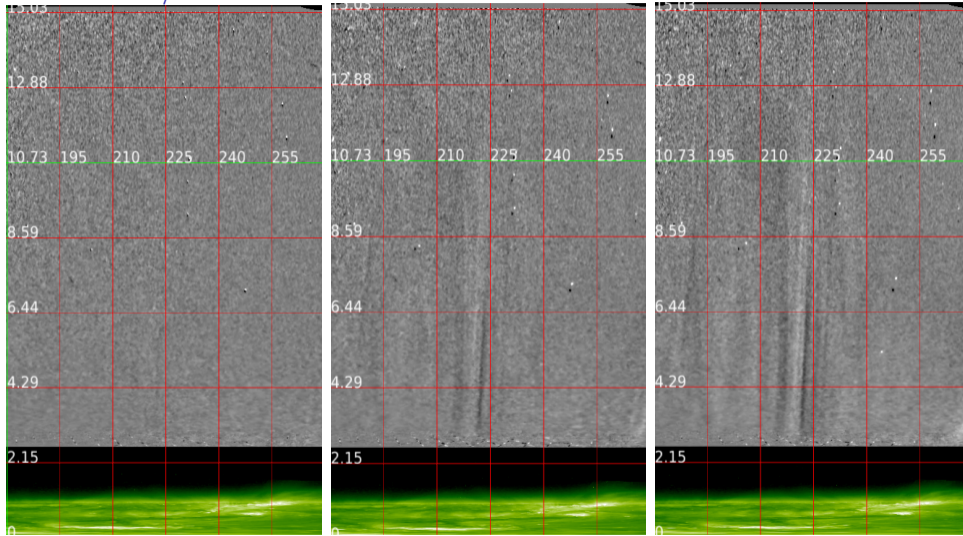


Figure: STEREO-A/COR2 Base Difference 2022-03-07 15:30 to 18:20

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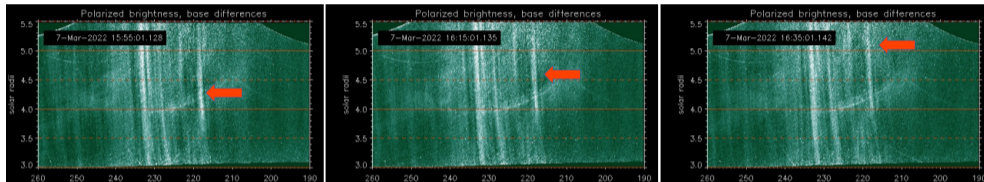


Figure: SOLO/Metis Base Difference 2022-03-07 16:15 to 16:55

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K Corona

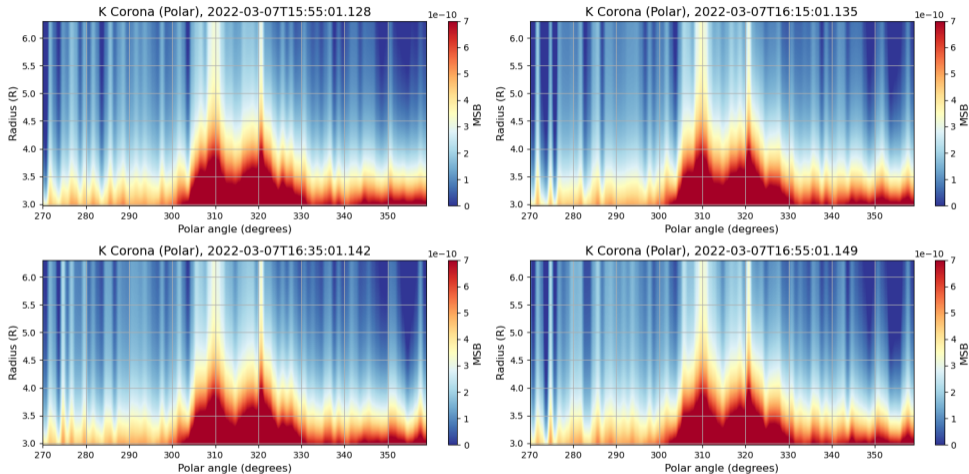


Figure: Computation of K corona using Metis observations [Hayes et al., 2001]

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- ▶ Applying PFSS extrapolation with HMI vector magnetogram of 12m cadence we find that AR NOAA 12957 has magnetic field configuration of both open and closed lines - AR next to CH.

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- ▶ Applying PFSS extrapolation with HMI vector magnetogram of 12m cadence we find that AR NOAA 12957 has magnetic field configuration of both open and closed lines - AR next to CH.
- ▶ From 2022-03-03 until 2022-03-05 the AR of interest is at disk center, hence any ejection is not visible in coronagraphs' FOV.

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- ▶ From 2022-03-03 until 2022-03-05 the AR of interest is at disk center, hence any ejection is not visible in coronagraphs' FOV.
- ▶ On 2022-03-06 00:00 UT there is a strong radioburst type III along with in situ measurements of ions and a narrow CME seen by LASCO. No Metis observations available.
- ▶ On 2022-03-07 a flare of class C and a deem radioburst were observed. No in situ measurements by SOLO/SIS because magnetic connection has dropped. Coronagraph observations reveal structures likely related to the event.

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- ▶ This type of study is challenging - One has to use observations from multiple instruments.

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- ▶ This type of study is challenging - One has to use observations from multiple instruments.
- ▶ Using Metis data we show that it is possible to detect faint structures and relate them to activity from an AR.

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- ▶ This type of study is challenging - One has to use observations from multiple instruments.
- ▶ Using Metis data we show that it is possible to detect faint structures and relate them to activity from an AR.
- ▶ Next step: Use observations from SOLO/SPICE.

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Hayes, A. P., Vourlidas, A., and Howard, R. A. (2001).

Deriving the Electron Density of the Solar Corona from the Inversion of Total Brightness Measurements. *JGR*, 548(2):1081–1086.



Schatten, K. H., Wilcox, J. M., and Ness, N. F. (1969).

A model of interplanetary and coronal magnetic fields. *JGR*, 6(3):442–455.



Wang, Y. M., Pick, M., and Mason, G. M. (2006).

Coronal Holes, Jets, and the Origin of ^3He -rich Particle Events. *JGR*, 639(1):495–509.

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Thank You!

Angelos Michailidis

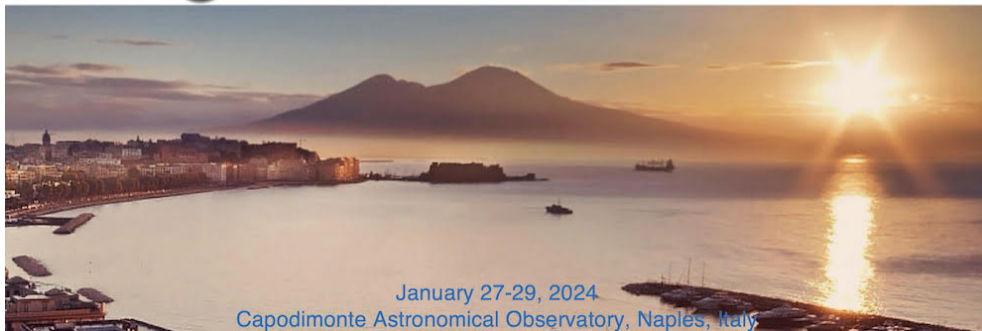
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II Metis Science Meeting



January 27-29, 2024

Capodimonte Astronomical Observatory, Naples, Italy

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