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MESOM: A MOON-ENABLED SUN OCCULTATION MISSION

Abstract

The study of the solar corona has important ramifications on the understanding and forecasting of potentially catastrophic events such as solar flares and coronal mass ejections. Yet, regardless of scientific breakthroughs brought by space-based coronagraphs and solar observatories, access to the lowest layers of the Sun's atmosphere remains elusive. Because of vignetting and stray light effects, visible-light measurements between 1 and 2 solar radii are mostly collected during total solar eclipses on Earth. These are extremely rare events that typically last for a few minutes and only happens once every 18 months, on average.

An alternative approach, first proposed by Eckersley and Kemble, advocates creating artificial total eclipses in space by means of a spacecraft flying in the shadow of a spherical, airless, celestial object such as the Moon. This paper introduces the preliminary trajectory design analyses and trade-off studies of a Moon-Enabled Sun Occultation Mission (MESOM). By means of synodic resonant orbits that exists in the chaotic dynamics of the Sun-Earth-Moon system, trajectories capable of delivering 21 minutes per synodic month (29.6 days circa) of manoeuvre-free solar corona observations below 1.04 sun radii were identified and used as a baseline for the preliminary design of a 2+ year-long satellite mission.

The proposed science payload is based on a heritage of total eclipse instrumentation, thus at a ground-based TRL of 9. A broadband visible polarizing imager will give high resolution images of the solar atmosphere from very close to the photosphere to large distances (x8 sun radii), thereby enabling studies of fine-scale magnetic structures and their connection to the Sun. In parallel, a multi-channel spectrometer will provide high spectral resolution data of the Fe emission lines, giving line-of-sight velocities, and non-thermal broadening diagnostics.

The science instrumentation is simple and low-risk. Using the Moon as a natural occulter avoids the

technical challenges of a coronagraph optical system and contributes to mitigate some of the design issues and pointing requirements of large-scale solar coronagraph missions. Indeed, MESOM does not require coronagraphic capabilities, and, given an appropriate orbit, will collect high-resolution high-quality data of the inner sun corona for more than 35 total solar eclipses on Earth. These unprecedented measurements will fill a gap in current existing spaceborne capabilities and unlock a better understanding and forecasting of adverse space weather phenomena.