Paper ID: 49270
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26th IAA SYMPOSIUM ON SMALL SATELLITE MISSIONS (B4)
Small Space Science Missions (2)

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POLARIMETRY TO UNIFY THE CORONA AND HELIOSPHERE (PUNCH) MISSION DESIGN

Abstract

PUNCH (Polarimetry to UNify the Corona and Heliosphere) is a NASA Heliophysics SMall EXplorer (SMEX) mission that will launch in 2022 August. Four micro-satellite class Observatories orbit in a 570 km altitude Sun synchronous terminator orbit. Each spacecraft hosts one instrument: either a Wide Field Imager (WFI) or a Narrow Field Imager (NFI). There are 3 WFI Observatories, and 1 NFI Observatory. The mission lasts two years, during which the 4 instruments act as a single virtual instrument, nearly constantly imaging the solar heliosphere from about 1 degree away from the Sun to about halfway to the Earth. A Pegasus XL is expected to launch the 4 Observatories into the operational orbit. During launch and ascent, the Observatories are in the stowed configuration, unpowered, and attached to a Separation Module. Upon reaching orbit, the Observatories separate in pairs, with the first pair largely aligned with the orbital and anti-orbital velocity vector. The second pair is largely aligned to the orbital normal vector, one on each side of the orbital plane. 90 days of spacecraft and instrument commissioning, and science data validation/calibration ensue. During this time, the 4 PUNCH Observatories move away from each other. When the 3 WFI Observatories are approximately equally spaced in orbit, small propulsive maneuvers lock them in place. The resulting virtual instrument fields of view form a rotating tri-foil that images the entire heliosphere to 45 degrees elongation, once per orbit. The NFI instrument is a compact coronagraph, developed by the US Naval Research Laboratory. The WFIs are heliospheric imagers, developed by the Southwest Research Institute (SwRI). The spacecraft, Mission Operations Center, and Science Operations Center are also developed by SwRI. The 2 year science operations phase of the mission is highly repetitive and automated. The 98 minute orbital period is divided into 12 segments, of approximately 8 minutes each. During each segment, the NFI takes two sets of polarized images, and one clear image. At the same time, each WFI instrument also takes two sets of polarized images, and one clear image. The images are downloaded to Earth, then processed to reveal evolving structures within the expanding heliosphere. The purpose of the mission is to understand how the young solar wind evolves over time. PUNCH is expected to revolutionize our understanding of heliophysics, by unifying flow out of the solar corona into the solar heliosphere.