In-Situ and Remote Sensing of Space Plasmas – Science, Technology and Instrumentation

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In the vast space environment, space plasmas can be fully or partially ionized. In situ sensing is typically carried out using spacecraft instrumentation that measures 3D particle distributions across a broad energy range, from thermal to high-energy tails. Remote sensing of plasmas becomes possible when hot ionized plasmas coexist with a cold background of neutral gas, undergo charge exchange, and glow as energetic neutral atoms (ENAs). Because these ENAs can travel large distances unimpeded by electromagnetic forces, they can be used to infer the properties of the source plasmas. This talk will present two new instruments: the NASA/GSFC Ion and Neutral Mass Spectrometer (INMS), scheduled for launch into a LEO/VLEO orbit in Q4 2027, and the Storm Time O+ Ring current Imaging Evolution (STORIE) ENA instrument, scheduled for launch to the ISS on May 12, 2026.

The INMS is hosted on a rideshare spacecraft that will launch into a 98° inclination orbit at a 550 km altitude, gradually spiraling down to 250 km before a controlled end-of-life dive. Based on time-of-flight technology, the INMS measures both ion and neutral mass composition and densities in parallel. It covers a mass range of 1-60 amu with 1 amu resolution and is optimized for the largely unexplored Very Low Earth Orbit (VLEO) environment. Systematic ion and neutral mass density composition measurements in VLEO do not currently exist, yet they are critical for understanding the connections between space weather and Earth's weather, as well as for modeling satellite atmospheric drag.

The STORIE ENA instrument employs a large aperture (geometric factor $\tilde{0}.5$ sr·cm$^{\mathbf{2}}$) with a 1D field of view (4° x 100°) oriented approximately north-south. It leverages the motion of the ISS, acting like a push-broom, to perform full inside-out global Geospace remote sensing during the 90-minute orbital period of the ISS. The instrument uses electrostatic deflection to reject charged particles alongside multi-foil/MCP time-of-flight technology, utilizing multi-time coincidence and pulse height analysis (PHA) to separate H and O ENAs in the $\tilde{1}$ keV to 200 keV energy range. STORIE also features a specially developed UV filter to reject UV light and other background noise, and it leverages the high-rate, real-time telemetry of the ISS for detailed data downlinks and simplified commanding and operations. Line-of-sight ENA measurements, combined with neutral exosphere data and inversion techniques, will be used to calculate the source ion populations. STORIE operates in excellent synergy with the recently launched Carruthers Geocorona Observatory mission, which aims to measure Earth's neutral H exosphere responsible for the ENA glow. It is also highly synergistic with the recently launched NOAA SWFO-L1 and IMAP missions, helping to relate the Geospace response to solar wind drivers for the benefit of global science and space weather forecasting.