

Observations of Decameter Small-Scale Structures in the Auroral Ionosphere: From Sounding Rockets to CASSIOPE Enhanced Polar Outflow Probe (e-POP)

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High-resolution particle and field observations from a number of recent and earlier sounding rockets have revealed a host of sub-decameter small scale structures in the topside auroral ionosphere. These include localized lower hybrid waves or “spikelets” and density cavities that often coincide with localized regions of perpendicular ion conics of tens of meters width. At the same time, high-resolution ground-based imaging has documented the existence of a large variety of highly dynamic small-scale structures within the visible aurora, including auroral filaments, curls, and spirals. Also of interest are features associated with extremely rapid motions (>10 km/s) and temporal variations (time constants of 1- 60 s) that have apparent widths on the order of 10 - 100 m at the magnetic zenith, and thin auroral curtains of 0.1-1 km thickness. Such structures suggest the presence of auroral acceleration processes on the scale size of the electron or ion inertial length. An important question is the micro-scale relationship between auroral ion bulk upflow, heating, and acceleration in the topside ionosphere on the one hand, and the associated auroral emissions, field-aligned currents, and plasma waves on the other. The spatial resolution of auroral images onboard existing orbiting satellites is typically on the order of tens of kilometers, and insufficient to resolve such structures. In this paper, we review these observations, and discuss the questions that they raise in the context of the Enhanced Polar Outflow Probe (e-POP) small satellite mission, which will provide a unique opportunity for probing small-scale particle, field, and auroral structures from an orbiting platform.

The scientific objectives of e-POP are to quantify the micro-scale characteristics of plasma outflow and related micro- and meso-scale plasma processes in the polar ionosphere, explore the occurrence morphology of neutral escape in the upper atmosphere, and study the effects of auroral currents on plasma outflow and those of plasma microstructures on radio propagation. The e-POP payload will be placed in a low-altitude, elliptical polar orbit (80° inclination, 300 km perigee, and 1500 km apogee). The e-POP science instrument payload is a suite of 8 scientific instruments, including imaging plasma and neutral particle sensors, magnetometers, radio wave receivers, dual-frequency GPS receivers, CCD cameras, and a beacon transmitter. The imaging plasma sensors will measure particle distributions and the magnetometers will measure field-aligned currents on a time scale of 10 ms and a spatial scale of ~ 100 m. The CCD cameras will perform auroral imaging on a time scale of 100 ms. Thus, the particle, field, and optical observations on e-POP will provide a unique opportunity with which to resolve the temporal and spatial structures of various decameter or sub-decameter scale processes in the auroral ionosphere.