Sub-5km baseline tomography for fine-scale auroral measurements

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Auroral morphologies are a direct result of the specific energy levels driving the optical emissions as well as the spreading of wave energy. The emphasis of the present work is on identifying apparent auroral feature motion in both the $\mathbf{B}_{\parallel}$ and $\mathbf{B}_{\perp}$ dimensions in order to uncover the physical model responsible for wave spreading under the given electron beam excitation. The auroral $\mathbf{B}_{\parallel}$ dimension is known to experience a change in shape and peak optical emission for given electron beam energies, and forward models have been previously established for these phenomena. The transverse proper motion of auroral features is related to spreading of energy in the $\mathbf{B}_{\perp}$ direction. Several theories have been advanced to explain the auroral transverse proper motion, but previous observational efforts have been limited to temporal scales on the order of a second. Our new observational facility is capable of simultaneously resolving features to the decameter scale spatially and millisecond scale temporally–a capability not available until now thanks to recent advances in Electron-Multiplying Charge Coupled Device (EMCCD) technology that are triggerable with sub-millisecond accuracy from GPS-disciplined trigger sources. We can thereby combine multiple simultaneous 2D optical observations with arbitrarily physical separation to take tightly time-synchronized observations of extremely faint optical phenomena for tomographic inversion.

We present measurements and initial characterization of a new high-speed auroral tomography system implemented for auroral arc measurements in Alaska. This system is comprised of two EMCCD cameras on the Poker Flat Research Range (PFRR) to reveal the 3D location of the peak auroral brightness via tomographic techniques. Auroral features are resolved with better than 1 millisecond timing precision between 2 sites with a 3km baseline using a 9 degree field of view at up to 53 frames/second. Building upon knowledge gained from previous multiscale auroral measurements in Greenland, we discuss the tradespace of SNR, frame rate and spatial resolution. We provide tomographic analysis of the structure and motion in the aurora at sub-100-m scales.