Telescopic imaging of upper atmospheric streamer and diffuse glow dynamics

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Telescopic imaging shows that decameter-scale structure in luminous lightning-related discharges above thunderclouds (known as "sprites") covers a wide range of morphologies and time scales. Hundreds of sprites have been observed by the Stanford University telescopic imager. Certain categories of structures have been found to occur such as upward and downward branching, beading, propagating diffuse glow striations and streamer/diffuse glow transition regions. During the summers of 1998-2000, Stanford University deployed a telescopic imaging system, consisting of a ~41 cm diameter, f/4.5 Dobsonian-mounted Newtonian reflecting telescope with an intensified CCD camera attached to its eyepiece, a bore-sighted wide field of view (FOV) camera mounted on its top, and both telescopic and wide field of view photometers. The FOV of the telescope (0.5 in CCD) was ~0.7 degrees by ~0.92 degrees while that of the bore-sighted camera (.33 in CCD, 50 mm lens, f/1.4) was ~9 degrees by ~12 degrees. The system was deployed in both New Mexico and Colorado. Electromagnetic signatures of causative lightning discharges known as radio atmospherics (or sferics) were recorded using crossed-loop magnetic antennas and an ELF/VLF receiving systems located at Stanford and in Colorado. Using the telescopic imaging system we find that sprite structure can assume a wide variety of shapes, sizes, and time scales, but certain structures such as beading, faint downward branching, bright upward branching, propagating diffuse glows, and columns appear repeatedly. Propagating diffuse glow striations are observed to move slowly and are similar to the phenomenon observed in glow discharge tubes. While many streamers move at velocities greater than the time resolution of regular video rate imaging, some have been found to move as slowly as 10^4 m/s. Fine beading exists in many negative streamers and may possibly be a result of meteoric dust particles in the upper atmosphere. Columniform sprites may originate from positive branching streamers. Beads at the base of columns can glow for over 100ms while slowly drifting upward. Faint positive streamers are observed at the base of large bright sprites. Some sprites having branching positive streamers and non-branching negative streamers may be double-headed streamers initiated from plasma enhancements. A transition region between streamer formation and diffuse glow is observed at ~ 80km altitude.

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