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Modeling and Simulation of Lightning Related Transient Luminous Events at High Altitude in the Earth's Atmosphere

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Transient luminous events are large-scale optical events occurring at high altitude in the Earths atmosphere, which are directly related to the electrical activity in underlying thunderstorms. Several different types of transient luminous events have been documented and classified. These include relatively slow-moving fountains of blue light, known as 'blue jets', that emanate from the top of thunderclouds up to an altitude of 40 km; 'sprites' that develop at the base of the ionosphere and move rapidly downwards at speeds up to 10,000 km/s; 'elves', which are lightning induced flashes that can spread over 300 km laterally, and upward moving 'gigantic jets', which establish a direct path of electrical contact between thundercloud tops and the lower ionosphere. This presentation focuses of the modeling efforts at Penn State directed on interpretation of morphological electrical gas discharge features observed in sprite events. After a brief review of similarity properties of electrical discharges as a function of gas pressure, we introduce parameters typically used for quantitative description of electron avalanches and discuss importance of space charge effects on different spatial scales, including sprite halos (exhibiting 10s of km transverse extents) and sprite streamers (requiring sub-meter resolution for accurate description). A special emphasis is placed on interpretation of initiation and development of sprite streamers captured in high-speed video observations and critical review of the recent modeling efforts related to these observations.