High-speed Measurements of Evolution and Propagation of Fine Structure in Sprites

Robert A. Marshall, Umran S. Inan
STAR Laboratory, Stanford University

Observations of sprites recorded at frame rates of 1000 frames per second (fps) and higher provide evidence that some features of sprites are naturally-occurring streamer breakdown processes, propagating at speeds of ~10^7 m/s. Independent measurements of sprite features using telescopic imagery shows that sprites are often composed of a multitude of fine structure, including so-called "beads", as well as these streamer-like structures. In July and August 2004, the first successful images of sprites were recorded at Langmuir Laboratory, in New Mexico, USA, which combined high-speed and telescopic imaging techniques, in order to image small scale (~10 m) features of sprites at 1000 and 2000 fps. These images show a variety of structure and evolution of individual features, and show that while streamer-like structures persist on average only 1-2 ms, beads typically persist for 6-7 ms, and sometimes up to 50 ms. Furthermore, beads are not seen to propagate in this data set, while streamer propagation cannot be adequately resolved with the imaging system used. With the aim of either directly measuring propagation of streamers, and more generally to assess the notion that vertically-stratified structures in sprites are indeed plasma streamers, an experiment is planned for Summer 2005 to repeat the high-speed telescopic imaging of sprites at frame rates upwards of 10,000 fps. With a field-of-view comparable to that used in the 2004 campaign, the higher frame rate will allow direct observations of propagation of features up to 2.5 × 10^7 m/s, higher than the 10^7 m/s previously observed and theoretically predicted.

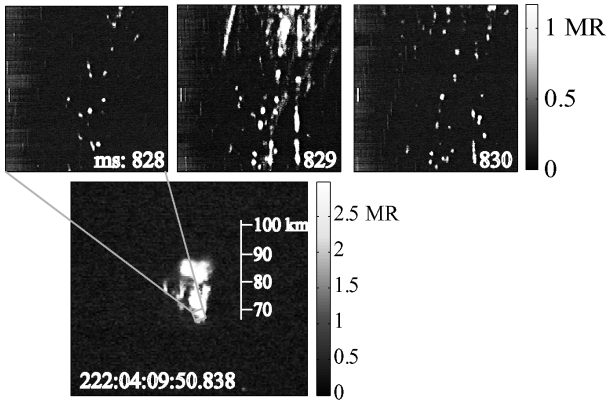

Figure: Sprite features recorded August 09, 2004, at 1000 fps.