EFFECTS OF PHOTOIONIZATION ON SIMILARITY PROPERTIES OF STREAMERS AT VARIOUS PRESSURES IN AIR

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Similarity relations [e.g., Roth, Industrial plasma engineering, Vol. 1, 1995, p. 306] represent a useful tool for analysis of gas discharges since they allow to use known properties of the discharge at one pressure to deduce features of discharges at variety of other pressures of interest, at which experimental studies may not be feasible or even possible. In addition to traditional design of glow discharge tubes, similarity relations have been successfully applied to understanding of streamer discharges in air at several atmospheres, which are used for triggering of combustion in spark ignition engines [Achat et al., J. Phys. D: Appl. Phys., 25, 661, 1992; Tardiveau et al., J. Phys. D: Appl. Phys., 34, 1690, 2001], and also for analysis and interpretation of streamer discharges in sprites occurring at very low air pressures in altitude range 40-90 km in the Earth's atmosphere [e.g., Liu and Pasko, JGR, 109, A04301, 2004]. Streamer discharges similar to those documented in sprites [Gerken and Inan, IEEE Trans. Plasma Sci., 33, 282, 2005, and references therein] have been observed in point-to-plane discharge geometry in laboratory experiments at near ground pressures [Pancheshnyi et al., Phys. Rev. E, 71, 016407, 2005; Briels et al., IEEE Trans. Plasma Sci., 33, 264, 2005]. Understanding of the physical processes which lead to the observed departures from similarity relations at different pressures in these experiments represents an important problem, resolution of which would synergistically benefit understanding of streamers in both systems (i.e., due to generally relaxed requirements on time resolution of imaging systems needed for studies of sprite streamers, and easy repeatability of discharges in high pressure laboratory experiments). In this talk we report results from a streamer model developed in [Liu and Pasko, JGR, 109, A04301, 2004; GRL, L05104, 2005; J. Phys. D: Appl. Phys., in review, 2005] as applied to propagation of positive streamers at various pressures in air in a point-to-plane discharge geometry. We directly compare our results with recent experiments at atmospheric and near atmospheric pressures in air reported in [Pancheshnyi et al., 2005; Briels et al., 2005]. The modeling results emphasize that the quenching of singlet excited states of molecular nitrogen emitting photoionizing radiation is responsible for non-similar behavior of streamers at pressures higher than several Torr. Our modeling results agree with recent experimental work [Pancheshnyi et al., 2005; Briels et al., 2005] showing that streamers have more and thinner channels and branch more frequently at higher (i.e., near atmospheric) pressures than at lower pressures. The results also demonstrate importance of accounting for effects associated with electrode geometry for interpretation of experimental studies on similarity properties of streamers at various pressures. One of the major unsolved problems in current sprite research is the observed initiation of sprites by very weak lightning discharges [e.g., Hu et al., GRL, 29, 1279, 2002]. It has been proposed that meteoric dust particles in the mesosphere and stratosphere may be involved in the formation of sprites [Zabotin and Wright, GRL, 28, 2593, 2001]. In this talk we will also discuss the implications of the experimental results of Briels et al. [2005] and our related modeling studies for the meteoric dust theory of sprite initiation.

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2. H - Waves in Plasma

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4. C - Contributed Paper, Program chair: E. Gerken and V. Pasko

5. No special instructions