Photoionization of Metallic Species at Sprite Altitudes by far-UV Emissions of LBH band System of Molecular Nitrogen

Victor P. Pasko
Communications and Space Sciences Laboratory, Penn State University, University Park, Pennsylvania, USA

The N2 Lyman-Birge-Hopfield (LBH) band system has emission spectrum in the range 120-280 nm [e.g., Vallance Jones, A. V., Aurora, Springer, 1974, p. 134]. These emissions are produced by sprite discharges as documented by observations using ISUAL instrument on FORMOSAT-2 satellite and modeling [e.g., Liu et al., GRL, 33, L101101, 2006, and references therein]. These emissions are not observable from the ground or from an aircraft due to strong absorption by O2, however, due to their relatively low excitation threshold (8.55 eV) these emissions are abundantly produced in sprites [Liu et al., JGR, 114, A00E02, 2009]. As a result of meteoric ablation Fe, Mg, Si, Na, Ca and K atoms form well defined layers in the Earths atmosphere [Plane et al., Chem. Rev., 115, 4497, 2015], and the overall injection rates of these elements form broad peaks in the altitude range between 70 and 120 km [Plane et al., Space Sci. Rev., 214, 23, 2018]. The local concentration of these elements is expected to depend on meteor mass, velocity, altitude of deposition and also on the stage of meteor trail expansion. Although these elements initially appear in ionized form, the ions quickly oxidize and then recombine with electrons resulting in the neutral atomic form of these species [Silber et al., MNRAS, 469, 1869, 2017 and references therein] with typical lifetimes measured in hours [Plane et al., Chem. Rev., 115, 4497, 2015]. In terms of relative concentration Fe, Mg and Si typically dominate, followed by Na, Ca and K [Granier et al., GRL, 16, 243, 1989; Plane et al., Space Sci. Rev., 214, 23, 2018]. It is remarkable that all these species have ionization potentials and the related threshold wavelength Fe (7.9 eV, 157 nm), Mg (7.64 eV, 162 nm), Si (8.15 eV, 152 nm), Na (5.13 eV, 242 nm), Ca (6.11 eV, 203 nm) and K (4.34 eV, 286 nm) allowing them to be effectively photionized by 120-280 nm N2 LBH emissions. In this talk we report development of modeling framework for calculations of related photoionization rates at sprite altitudes and discuss applicability of these processes to understanding of initiation of streamers in sprites, and also to understanding of small morphological features observed in sprites as well as branching of sprite streamers.