Evolution of nonlinear electrostatic structures in the lunar wake region

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Dust is an ineluctable component in space and astrophysical environments. Over the last few decades, the physics of dusty plasmas has attracted growing interest, focusing on elucidating its properties and investigating the associated (e.g. electrostatic) modes and instabilities, because of their essential importance in space and astrophysical plasmas (e.g., in planetary magnetospheres) and in laboratory plasmas [1-2]. On the other hand, satellite observations have confirmed the ubiquitous presence of energetic particle populations e.g. in the solar wind, manifested in long tailed (non-Maxwellian) particle distributions [3, 4]. It is now established that the vicinity of the sunlit lunar regolith is in a plasma state consisting of photoelectrons and positively charged dust particles (exclusively) [5,6]. This two-component system essentially constitutes the lunar exosphere over the sunlit locations of the Moon.

By incorporating charge fluctuations into photoelectron–dust dynamics, we have developed an analytical model for the lunar exospheric plasma to describe the propagation of long-wavelength dust acoustic (DA) modes. Based on a fluid simulation algorithm [7], we have developed a simulation code to investigate the evolution of DA waves in the presence of superthermal electrons in the sunlit lunar region. Beyond this successful example, our findings should be directly applicable in various dusty plasma situations in planetary environments.

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