

Stochastic dust charging in multicomponent plasmas: Impact of energetic electron populations on charge fluctuations

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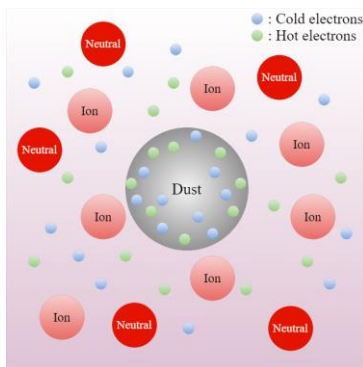
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Dust grains are ubiquitous in both laboratory and astrophysical plasmas, where their charging dynamics fundamentally influence plasma behavior and the emergence of complex phenomena. This study examines the statistical nature of dust charge fluctuations in a multicomponent non-Maxwellian hydrogen plasma, consisting of two distinct electron populations (cold and hot), positive ions, and dust grains, as depicted in figure 1. By employing a discrete numerical model that extends the classical Cui-Goree approach [1], the work captures the inherently stochastic process of charge accumulation, where individual electrons and ions are collected at random intervals. The comparison between the continuous and discrete models, as shown in Figure 2, highlights that the discrete approach not only reveals pronounced charge fluctuations but also demonstrates that the presence of non-Maxwellian, energetic electrons increases the overall negative charge on dust grains and

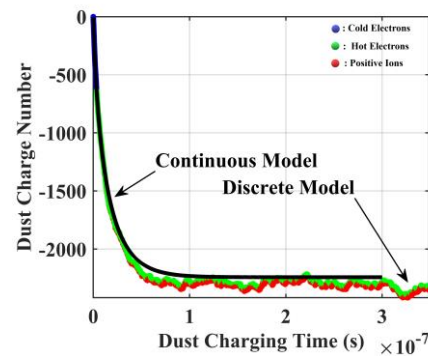
significantly reduces the dust charging time [2]. Systematic analysis reveals that the electron energy distribution, plays a pivotal role in determining the magnitude and variability of dust charge, with even modest deviations from Maxwellian statistics substantially enhancing charge fluctuations. These results underscore the importance of discrete dust charging models and non-Maxwellian electron populations for accurately describing real plasma environments, offering new insights relevant to plasma processing and fusion edge physics [2].

References

- [1] C. Cui, and J. Goree, IEEE Transactions on Plasma Science 22 (151-158) 1994.
- [2] R. Paul, G.Sharma, K.Deka, S. Adhikari, R. Moulick, S. S. Kausik, B.K.Saikia, Physica Scripta 99, (065602) 2024.



(1)



(2)

Figure: (1) Schematic diagram of dust charging in presence of two electron groups. (2) Temporal evolution of dust charge number in the presence of Maxwellian cold electrons and positive ions, non-extensive hot electrons.