MODELLING THE AEROSOL-PLASMA INTERACTION

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We discuss how aerosol (dust) particles interact with the ambient mesospheric plasma, and in particular how small-scale aerosol density fluctuations impact the plasma and can cause Polar Mesospheric Summer Echoes (PMSE).

The high mobility of electrons, and the much lower mobility of ions, lead to rapid negative charging of aerosol particles. This charging has two effects on the ambient plasma: It modifies reaction rates and thus the ionization equilibrium of the plasma, and, secondly, small-scale charged aerosol density fluctuations induce ambipolar flow in the plasma which leads to density fluctuations in the ambient ions and electrons.

We have used a one-dimensional, time-dependent numerical model to study this interaction. The model solves the continuity and momentum equations for neutral and charged aerosols, positive ions, and electrons, and include attachment of electrons and ions by aerosols, diffusion of aerosols, ions and electrons, and gravitional settling. The model therefore encompasses the huge range of time scales involved, from the (sub-) second time scale of electron attachment, to the aerosol diffusion time scale which can be of order hours or days. On the length scales most relevant to PMSE, of order a few meters, electron and ion ambipolar flow in response to aerosol density gradients is usually the dominant process.

The main result is that small-scale aerosol density fluctuations induce small-scale electron density fluctuations of the same magnitude, which can cause PMSE. The lifetime of the electron density fluctuations is equal to the aerosol diffusion lifetime, of order hours or more. Moreover, the lifetime is independent of the aerosol density, which explains the observed fact that most PMSE are detected when the aerosol density is much smaller than the ambient electron density. The ambipolar flow in the presence of aerosol fluctuations also causes an anticorrelation between electron and ion density perturbations, in agreement with most in situ rocket observations. We therefore believe we now have a good understanding of how aerosol particles in the mesosphere affect the ambient plasma. In order to explain PMSE, the main issues remaining are therefore to understand how aerosols are formed, and how small-scale aerosol fluctuations are created in the first place.

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2. H - Waves in Plasma

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4. I - Invited Paper, Program chair: M. Horanyi

5. No special instructions