Recent Theoretical and Experimental Developments in the Investigation of Polar Mesospheric Summer Echoes (PMSE) and their Relation to Charged Dust

Cesar La Hoz and Ove Havnes

University of Tromso, Norway (Cesar.La.Hoz@phys.uit.no)

Polar Mesospheric Summer Echoes, or PMSE, are strong radar echos from the cold high latitude mesosphere during summer. Known since about 1980, the phenomenon is not yet fully understood. A breakthrough occurred in 1996 when Havnes et al. employing rockets detected charged dust particles under PMSE conditions, presumably ice. These developments opened new opportunities to explain the phenomenon via some of the rich interactions that take place in a complex plasma environment. A striking example is the PMSE overshoot effect caused by cycling of artificial RF heating of the mesospheric electrons predicted and confirmed by Havnes et al. The variation of electron diffusion rate and dust charge number due to the electron temperature modulation, causes, in turn, a weakening and strengthening (overshoot) of PMSE. Thus, there remains little doubt about the crucial role that charged dust plays in maintaining PMSE, despite a lack of direct measurements of its size, charge number and composition, which are decisive parameters to validate theories. Even with these important advances, a consistent theory of PMSE is still lacking, as will be shown.

One of the most attractive theories of PMSE assumes that the electron fluctuations that cause the scattering are driven by neutral turbulence. Charged dust makes possible the extension of the electron turbulence spectrum - via ambipolar forces that slow electron diffusion - to include scale sizes (detected by the radars) that otherwise would not exist. Yet, recent experiments performed with the EISCAT radars reveal important disagreements with calculations that follow this theory. The measured scattering cross-section at VHF scales is stronger than that at UHF by a factor of several thousand, in contrast to the theoretical prediction of about 70. Measured turbulence dissipation rates at UHF scales, when combined with the theory, results in dust charge numbers of the order of 10, or more, in disagreement with reliable theoretical estimates of about unity. Furthermore, the slowing down of electron diffusion - due to the ambipolar forces of single charged dust - might not be sufficient to account for rocket observations of electron fluctuations causing PMSE in the absence of neutral turbulence .

Thus, although there is little doubt that charged dust in the mesosphere plays a decisive role in maintaining PMSE, we suggest that PMSE still remains largely unaccounted for by any theory.