# On the role of charged dust in the creation and maintenance of Polar Mesospheric Summer Echoes (PMSE)

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## Abstract

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 measured charged dust particles under PMSE conditions during visual and (lidar) sub-visual sightings of noctilucent clouds. These developments opened new opportunities to explain the phenomenon via some of the rich interactions that take place in a dusty or complex plasma environment. Ever since, there remains little doubt that charged dust plays a decisive role in creating PMSE, despite the lack of direct measurements of the individual dust particles, especially their size and charge number which are decisive parameters to validate/invalidate theories. The interest on PMSE has been spurred by the realization that visible noctilucent clouds began to appear for the first time by the end of the 19th century coinciding with the birth of industrialization, thus connecting both phenomena to global change (Thomas et al., 1989).

The PMSE overshoot effect caused by cycling of artificial RF heating of the mesospheric electrons predicted by Havnes (2004), and earlier confirmed experimentally, (Havnes et al., 2003) offers the promise to diagnose important PMSE environmental parameters, as for example electron temperature and dust charge number. A simple scattering model based on partial reflection reproduces the overshoot curve surprisingly well. The success of the overshoot effect in reproducing some of the properties of PMSE is perhaps the best indirect proof of the instrumental role that charged dust plays in the creation of PMSE.

A popular theory of PMSE assumes that the electron structures that cause the scattering are driven by neutral turbulence. A requirement at VHF frequencies and up is that the dust size/charge-number be large enough to extend sufficiently the convective-diffusive subrange of the electron turbulence via an enhancement of the Schmidt number. At UHF frequencies, e.g. the EISCAT 930 MHz radar, this requirement implies large dust charge numbers incompatible with reliable models and indirect measurements (La Hoz et al., 2005). The long electron diffusion times suggested previously in the literature (e.g., Rapp et al., 2000, 2003), necessary to explain PMSE at VHF frequencies in the absence of neutral turbulence, are probably too optimistic, or may, otherwise, require unlikely large charge numbers as well.

Thus, although there is no doubt that charged dust/aerosols in the mesosphere play a decisive role in creating PMSE, the actual mechanism is far from clear.

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