URSI AP-RASC, Sydney, Australia, 17-22 August 2025

Cosmic dust studies using plasma interactions in the heliosphere and ionosphere

Ingrid Mann[(1))]
(1) Inst. of Physics & Techn, UiT, ArcticUniversity Norway, Tromsø, Norway, 9019, ingrid.b.mann@uit.no

This talk gives an overview of new studies of cosmic dust in the inner heliosphere and ionosphere. Most of the recent results were derived from antenna and radio wave observations. Cosmic dust can be detected through plasma interactions when the particles hit a spacecraft at high speed. In the inner heliosphere, such impacts can be detected, for example, with antenna measurements. Antenna measurements that record dust impacts are currently made near Earth orbit with the STEREO and WIND spacecraft and inside Earth orbit with Parker Solar Probe and Solar Orbiter. The two latter space missions reach regions near the Sun that have never been visited by spacecraft before. Dust impacts into Earth atmosphere are observed through the meteor process, the interactions of the meteor plasma in the ionosphere are observed with radar.

The studies in the inner heliosphere reveal the basic physics of dust in the vicinity of a star where the dust is deflected in magnetic fields and interacts with the solar or stellar wind. Processes like dust sublimation and erosion by solar wind sputtering can be estimated based on the observational data. The dust observations in the inner heliosphere also shed some light on the evolution of the small objects in a planetary system because the observed dust particles are collision fragments of asteroids and comets. The spacecraft cross meteor streams and allow to estimate the size distribution of collision fragments. And the spacecraft observations discovered a component of the dust that is produced by collisions in the inner solar system and then pushed outward by the radiation pressure force. The obtained results allow to draw a comparison between the solar system dust cloud and the observations of dust disks around other stars in extrasolar planetary systems. More results are expected from the ongoing space missions as well as from missions with scheduled launches in 2025: Punch, IMAP and Destiny+.

While the flux of cosmic dust is barely noticed, it has an impact on the upper Earth atmosphere. In the Earth ionosphere, cosmic dust is observed in meteors, the transient events associated with the deceleration and decomposition of the particles. The dust material condenses to solid nm-sized particles. The meteoric particles are part of the mesosphere and lower thermosphere at an altitude of 60–120 km, where they influence ion chemistry and ice condensation. This region is very variable, especially at high latitudes, and is influenced by global change and space debris. Recent results made with radar and with rocket in-situ measurements will be presented. Potential impacts of the dust on the upper Earth atmosphere and potential implications in more genereal on the habitability of planets will be discussed.

Finally, the discussed observations also contain information on interstellar dust that streams into the solar system. The detection of interstellar dust in the solar system, the potential detection of interstellar meteors, and the observational challenges and the astronomical implications will be discussed.