INSTABILITY OF HIGHLY COLLISIONAL PLASMAS IN MAGNETIC FIELD: FROM THE LOWER EARTH'S IONOSPHERE AND METEORS TO SOLAR CHROMOSPHERE

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For many years, we have been studying theoretically and numerically nonlinear plasma processes in the weakly-ionized Earth's ionosphere. In the E region, located roughly between 90 and 130 km of altitude, ions so frequently collide with the dense neutral atmosphere that their magnetization becomes virtually destroyed, while electrons remain strongly magnetized. In the presence of a DC electric field, $\vec{E}_0$, perpendicular to the geomagnetic field, $\vec{B}_0$, these electrons freely $\vec{E}_0 \times \vec{B}_0$-drift, while the unmagnetized ions remain mostly attached to the neutral atmosphere. These two distinct streams create global currents called electrojets. If the DC field in electrojets is strong enough then it may drive there plasma instabilities. The instabilities, in turn, generate plasma turbulence that consists of density irregularities coupled with electrostatic field fluctuations. This small-scale turbulence gives rise to large-scale electron heating, observed by incoherent radars during geomagnetic storms and a recently predicted average nonlinear current. Both these macroscopic effects can modify significantly the high-latitude ionospheric conductance, affecting the global magnetospheric current system and the potential distribution.

Similar unstable processes take place in a dense meteor plasma formed largely at the same E-region altitudes. This plasma is created by meteoroids that enter the Earth's atmosphere with a hypersonic speed, then ablate, ionize, and vaporize, depositing in the atmosphere most of its dust material. The vast majority of meteoroids are so tiny that they cannot be observed optically. However, the meteor plasma created by them can be detected using high-power large-aperture radars through head echoes and non-specular trails. The former radar signal is wave scatter from a blob of plasma surrounding the descending meteoroid, while the latter represents wave scatter from electron density irregularities developing as a result of plasma instabilities in a slowly diffusing dense plasma column left behind the falling meteoroid.

Recently, it has also become clear that the same plasma instabilities can take place in the solar chromosphere characterized by similar plasma magnetization conditions. These instabilities can be driven by high-speed neutral flows ascending from the lower solar layers and crossing the local magnetic field. Macroscopic effects of these instabilities can be partially responsible for the sharp electron temperature increase by over 2000 K, observed spectroscopically just above the solar atmosphere temperature minimum. In this talk, we will review our recent theoretical developments in all these areas.