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He^{2+} transport in the Martian upper atmosphere with an induced magnetic field

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Solar wind helium may be a significant source of neutral helium in the Martian atmosphere. The precipitating particles also transfer mass, energy and momentum. To investigate the transport of He^{2+} in the upper atmosphere of Mars we have applied the Direct Simulation Monte Carlo method to solve the kinetic equation. We calculate the upward He, He^{+} and He^{2+} fluxes, resulting from energy spectra of the downgoing He^{2+} observed below 500 km altitude by the ASPERA-3 instrument onboard Mars Express. The particle flux of the downward moving He^{2+} ions was 1-2$\times 10^{6}$ cm^{-2} s^{-1}, and the energy flux is equal to 9-10$\times 10^{-3}$ erg cm^{-2} s^{-1}. The calculations of the upward flux have been made for the Martian atmosphere during solar minimum.

It was found, that if the induced magnetic field is not introduced in the simulations the precipitating He^{2+} ions are not backscattered at all by the Martian upper atmosphere. If we include a 20 nT horizontal magnetic field, a typical field measured by Mars Global Surveyor (MGS) in the altitude range of 85 km – 500 km, we find that up to the 30% - 40% of the energy flux of the precipitating He^{2+} ions is backscattered depending on the velocity distribution of the precipitating particles. We thus conclude that the induced magnetic field plays the crucial role in the transport of charged particles in the upper atmosphere of Mars and, therefore, that it determines the energy deposition of the solar wind.