R006-10
Zoom meeting B ：11/1 AM2 (10:45-12:30)
11:45-12:00

Modeling of SEP induced auroral emission at Mars: Different behaviors of electron and proton in the presence of crustal fields

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Since Mars lacks a global intrinsic magnetic field, Solar Energetic Particles (SEPs) can directly precipitate into its atmosphere, causing increased ionization, dissociation and excitation of the atmospheric molecules. Simultaneous observations with Solar Energetic Particle (SEP) and the Imaging UltraViolet Spectrograph (IUVS) instruments on board the Mars Atmosphere and Volatile EvolutioN (MAVEN) spacecraft have revealed the existence of SEP induced diffuse auroral emission spanning across nightside Mars [Schneider et al., 2015, 2018]. Several model studies showed that about 100 keV monoenergetic electron precipitation was preferable for the low altitude (~60 km) peak of the limb emission of CO2+ ultraviolet doublet [Schneider et al., 2015; Gerard et al., 2017; Haider et al., 2019]. However, no models were able to reproduce the low altitude emission peak using the observed electron energy population ranging from few keV to 200 keV. Previous auroral emission models did not take into account the contribution of MeV proton precipitation, although few MeV proton can penetrate into ~60 km altitude as well [e.g., Jolitz et al., 2017]. This study aims to model the SEP induced diffuse auroral emission by both electrons and protons to explain the observed diffuse auroral emission profiles. In order to constrain the possible source of the diffuse auroral emission, we focus on the different behaviors of electrons and protons in the presence of crustal fields due to a large difference in their gyro radii. Crustal fields on Mars largely change over an altitude range of precipitation, whereas Earth's global magnetic field did not change at all over the altitude range. Hence, the magnetic mirror plays a major role in altering the pitch angle of incident charged particles in the atmosphere of Mars, which is expected to affects the auroral emission profiles in the presence of crustal field.

In order to take into account the effects of crustal fields on the transport of electrons and protons, we have newly developed a Monte-Carlo collision and transport model of SEP electrons and protons with magnetic fields on Mars. We calculated following three modes: (1) a trace-only mode which solves equation of motion in the presence of three-dimensional inhomogeneous electromagnetic field without collision, (2) a collision-only mode which tracks all collisions in the absence of electromagnetic field and (3) a collision-trace mode which solves equation of motion in the presence of electromagnetic field and tracks all collisions. We focus on the SEP electrons with energy below 100 keV and protons with energy below 5 MeV due to the available energy range of the cross sections.

In a collision-only mode, we confirmed that 100 keV electrons and 5 MeV protons can penetrate into 60 km altitude, which is consistent with stopping height obtained by the previous models [e.g., Gerard et al., 2017; Jolitz et al., 2017]. We performed a case study of September 2017 event, using the energy population of electrons and protons observed by MAVEN/SEP. The ionization rate by protons is one order of magnitude larger than that by electrons, which suggests the auroral emission by protons can largely contribute to the total auroral emission.

Insights into the effects of crustal fields on the auroral emission by both electrons and protons will be shown at the presentation.