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Misbehaving high energy photoelectrons: Evidence in support of ubiquitous wave-particle interactions on Martian closed crustal magnetic fields

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Abstract

We use two years of MAVEN data to investigate previous results which showed that high energy (> 100 eV) photoelectrons were isotropic on closed crustal magnetic field lines. We found that low energies exhibit a typical source cone distribution expected from collisional scattering alone. However, high energies were peaked at perpendicular pitch angles. This gives strong support for ubiquitous wave particle interactions occurring in the Martian space environment as pitch angle scattering cannot produce this distribution alone. This will affect the amount and energy of precipitating electrons, and the heating and ionization rates in the neutral atmosphere below.

1. Introduction

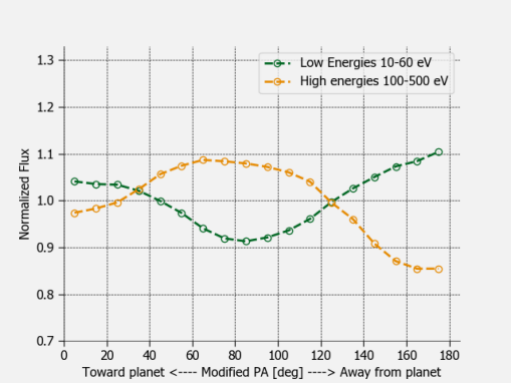
Pitch angle distributions (PADs) of photoelectrons observed over closed crustal magnetic fields are not to be expected from collisional scattering alone [1]. High energy photoelectrons (> 100 eV) were observed to be isotropic indicating an energy dependent pitch angle scattering process. Main neutral atmospheric constituents (CO_2 and O) have electron impact ionization cross sections that peak in this energy range. Any process that changes the PADs of electrons near these energies will affect the precipitation and consequences of (ionization, heating, excitation) in the atmosphere below.

2. Methodology

We used over two years of Mars Atmospheric and Volatile EvolutioN (MAVEN) data to understand the PADs of photoelectrons on closed crustal fields. We limited ourselves to measurements made above the photoelectron exobase (> 200 km) and where the spacecraft potential is low enough to not alter the measured distribution. Lastly, we required that the shape parameter developed by [2] indicates that photoelectrons are measured in both source cones. This constraint is used in order to ensure that we are making a measurement on a closed crustal field.

3. Results

We calculated the average pitch angle distribution for a given energy and found that low energy (10-60 eV) and high energy (100-500 eV) photoelectrons have very different average distributions (see figure). Low energy photoelectrons have a typical source cone distribution, while high energy photoelectrons are peaked at perpendicular pitch angles. A distribution peaked at perpendicular pitch angles cannot occur on the dayside without an energization process and we believe this is strong evidence for ubiquitous wave-particle interactions. This distribution will be investigated in different regimes of the Martian space environment in order to isolate the dependent variables.



References

[1] Liemohn M. W. et al. (2003) *JGR Planets*, 108, 5134

[2] Xu S. et al. (2017) *JGR Space Physics*, 122, 1831-1852