Sounder Accelerated Particles at Mars: Observations, Mechanisms, and Applications

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We report the first observations of sounder accelerated particles (SAP) in the ionosphere of a planet which does not possess a strong magnetic field (Mars). These observations were conducted onboard the Mars Express spacecraft by the ion and electron sensors of the Analyzer of Space Plasmas and Energetic Atoms (ASPERA-3) experiment and the powerful topside sounder: Mars Advanced Radar for Subsurface and Ionosphere Sounding (MARSIS). Accelerated ions (O²⁺, O⁺, and lighter ions) are observed in an energy range up to 800 eV when MARSIS transmits at a frequency close to the plasma frequency. Individual observations consist of almost monoenergetic ion beams either aligned with the MARSIS antenna or lying in the perpendicular plane. The observed ion beams are often accompanied by a decrease in the electron flux. Accelerated electrons are observed at energies up to 400 eV when MARSIS transmits at a frequency between the local plasma frequency and its harmonics (up to four times the plasma frequency). The majority of the sounder accelerated electrons are recorded close to the regions of intense crustal magnetic fields. The voltage applied to the MARSIS antenna causes spacecraft charging to 100's of volts by electrons from the ambient plasma. Positively charged ions are accelerated when the spacecraft discharges. Accelerated photoelectrons are released by the highly charged spacecraft and after one gyration in the strong magnetic field, return to the spacecraft which has already discharged. The acceleration effect influences which ions can be observed by increasing the energy of the thermal ion species making it possible to detect them whereas they would be indistinguishable under normal circumstances. We present the relevant data and discuss how these effects can be used for diagnostic of the local plasma.