EPSC Abstracts
Vol. 13, EPSC-DPS2019-51-1, 2019
EPSC-DPS Joint Meeting 2019

EPSC
EPSC-DPS Joint Meeting 2019
15–20 September 2019 | Geneva, Switzerland

Inverted-V electron acceleration events concurring with discrete aurora observations at Mars by MAVEN

Shaosui Xu (1), David L. Mitchell (1), James P. McFadden (1), Mathew O. Fillingim (1), Nick Schneider (2), Sonal Jain (2), David Brain (2), Tristan Weber (2), Laila Andersson (2), Christopher Fowler (1), Robert Lillis (1), Christian Mazelle (3), and Jared Espley (4)
(1) Space Sciences Laboratory, University of California, Berkeley, USA, (shaosui.xu@ssl.berkeley.edu), (2) Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder, Colorado, USA, (3) IRAP, CNRS - University of Toulouse - UPS - CNES, Toulouse, France, (4) NASA Goddard Space Flight Center, Greenbelt, Maryland, USA

Abstract

During late February to early March, 2019, the Imaging Ultraviolet Spectrograph (IUVS) onboard the Mars Atmosphere and Volatile EvolutioN (MAVEN) spacecraft repeatedly observed discrete aurora near periapsis over the southern strong crustal field region at Mars. During these orbits, the MAVEN Solar Wind Electron Analyzer (SWEA) observed accelerated electrons at similar locations to where the auroras were observed. These accelerated electrons resemble the inverted-V structure observed near the Earth's auroral region. In this study, we present a case study of such an inverted-V electron acceleration event, where we estimate a field-aligned electrostatic potential drop of around 400 volts. We estimate the field-aligned current from the observed magnetic perturbation and also the maximum current that can be carried by the plasma. We find that, similar to the terrestrial case, this potential drop, or double layer, occurs where the ambient plasma is unable to support the necessary field-aligned current, which at Earth is thought to result from magnetic reconnection and subsequent reconfiguration. This study demonstrates that a similar process is operating at Mars.

1. Introduction

Inverted-V electron acceleration events have long been observed at Earth, and are considered to be the source of discrete auroral emission. Electrons are accelerated by an electrostatic potential layer, or the double layer. This potential drop forms when the ambient plasma cannot support the needed field-aligned current. At Mars, similar electron acceleration events were observed by the Mars Global Surveyor spacecraft but corresponding observations of auroral emission were not available at that time [1]. Simultaneous auroral emission and accelerated electrons were observed by Mars Express, but the lack of magnetic field measurements made it difficult to determine if the electron acceleration mechanism is the same as at Earth. During late February to early March, 2019, the IUVS instrument onboard MAVEN repeatedly observed discrete aurora near periapsis over the southern strong crustal field region at Mars. During these orbits, SWEA observed accelerated electrons at similar locations to where the auroras were observed. In this study, we utilize the comprehensive particle and magnetic field measurements from MAVEN to investigate the acceleration mechanism for these inverted-V electron events.

2. Methodology

In this study, we use superthermal electron data from SWEA, magnetic field data from the Magnetometer (MAG), thermal electron density and temperature data from the Langmuir Probe and Waves (LPW) experiment. From the superthermal electron data, we infer the potential drop by examining the shift in energy in the electron phase space density. From the magnetic field data, we obtain the magnetic perturbation and estimate field-aligned currents. From the thermal electron density and temperature from LPW, we estimate the maximum current can be carried by the ambient plasma, along with the magnetic field strength along the flux tube estimated from the Morschhauser crustal field model [3].

3. Results and Conclusions

In this case study, we infer a potential drop of ~400 V from SWEA electron observations. Concurrent with electron acceleration, a magnetic perturbation of ~ 4.2 nT in the east-west direction was observed by MAG. The estimated field-aligned current is around 1-4 $\mu A/m^2$, which exceeds or is comparable to the maximum current that can be carried by the ambient cold plasma estimated from the LPW measurements in the altitude range of 200-500 km. The calculated current from magnetic perturbation is also upward, consistent with downward electron acceleration. It suggests that a potential is developed and accelerates electrons to provide the needed field-aligned current.

In summary, through a case study of inverted-V electron acceleration events concurrent with discrete aurora, we confirm that the same electron acceleration mechanism occurs at both Earth and Mars: a potential layer is formed when the ambient plasma cannot support the needed field-aligned current, and the accelerated electrons by this potential drop are likely to be the source of the observed discrete aurora.

References

[1] Brain, D. A., J. S. Halekas, L. M. Peticolas, R. P. Lin, J. G. Luhmann, D. L. Mitchell, G. T. Delory, S. W. Bougher, M. H. Acuña, and H. Reme (2006), On the origin of aurorae on Mars, Geophys. Res. Lett., 33, L01201, doi:10.1029/2005GL024782.

[2] Leblanc, F., et al. (2008), Observations of aurorae by SPICAM ultraviolet spectrograph on board Mars Express: Simultaneous ASPERA-3 and MARSIS measurements, J. Geophys. Res., 113, A08311, doi:10.1029/2008JA013033.

[3] Morschhauser, A., V. Lesur, and M. Grott (2014), A spherical harmonic model of the lithospheric magnetic field of Mars, J. Geophys. Res. Planets, 119, 1162–1188, doi:10.1002/2013JE004555.