MAVEN observations of small scale ionospheric irregularities in the Martian ionosphere and their statistical characteristics. C. M. Fowler¹, J. W. Bonnell¹, L. Andersson², J. D. Huba³, J. P. Thayer⁴, J. Espley⁵, D. Mitchell⁵, R. Lillis¹, J. McFadden¹, M. Benna¹, ¹Space Sciences Laboratory, University of California, Berkeley, CA, USA (cmfowler@berkeley.edu), ²Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder, CO, USA, ³Syntek Technologies, Fairfax, VA, USA, ⁴Univeristy of Colorado, Boulder, CO, USA, ⁵NASA Goddard Space Flight Center, MD, USA

Introduction: The dayside ionosphere of Mars is produced by the photoionization of atmospheric neutrals [1], while the nightside ionosphere is maintained through a combination of day-to-night transport and localized impact ionization [2, 3, 4] from precipitating electrons. Small scale ionospheric irregularities in ionospheric density and magnetic field strength have recently been observed by the NASA Mars Atmosphere and Volatile Evolution (MAVEN) mission [5, 6]. We present an example of one such event, demonstrating that atmospheric conditions are analogous to the terrestrial ionospheric E region, suggesting that the instability formation mechanism(s) may be similar to those that drive Type 1 and Type 2 irregularities at Earth, namely, the gradient drift and/or two stream instabilities [7, 8, 9, 10].

A statistical study of similar events at Mars using the ~4 year MAVEN data set has shed light on irregularity properties that are similar to the terrestrial analogues in some respects, and different in others. A striking feature at Mars is that variations in magnetic field strength are associated with these irregularities, in contrast to at Earth, where irregularities are electrostatic in nature. This is likely due to the Martian plasma beta having a value of ~1 in the ionosphere, compared to the much smaller values at Earth. The magnetic variations at Mars are typically 1-2 nT in amplitude, equivalent to 10-20% of the background field strength. The length scales of these magnetic variations are typically 5-20 km perpendicular to the magnetic field.

The plasma instrumentation carried by MAVEN cannot fully resolve the corresponding ionospheric density variations and it is not yet clear whether density variations mirror those in the magnetic field or not. Large variations in ionospheric density are none the less observed, typically at 25-75% of the background ionospheric density.

Ionospheric irregularity events at Mars are most likely to be observed past the dawn and dusk terminators, between solar zenith angles of 90 and 150 degrees, suggesting that as at Earth, photoionization acts to stabilize the ionosphere by reducing the vertical plasma density gradient. The magnetic environment at Mars is very different to Earth; Mars lacks a dipole magnetic field and possesses crustal magnetic fields; as a result, the magnetic environment is highly variable temporally and spatially, responding strongly to changes in upstream solar wind conditions, for example. At Earth, ionospheric irregularity events occur primarily at the magnetic equator where the local magnetic field is horizontal. Contrary to this, at Mars, irregularity events occur at all latitudes, primarily outside of the strongest crustal field regions. The exclusion of events within the strongest crustal field regions arises due to the large increase in magnetic field strength there, which acts to re-magnetize ions and stabilize the ionosphere against the gradient drift and two stream instabilities, at least at the altitudes sampled by MAVEN.

MAVEN is the first spacecraft at Mars capable of observing these small scale ionospheric irregularities using in-situ measurements, and the study of these events provides information into the coupling between the neutral atmosphere and ionosphere. The similarities and stark differences between the Martian and terrestrial plasma environments allows for interesting and insightful comparative aeronomy studies to be undertaken, and the results presented here are the first step in this process.