Exploring the ionosphere of Mars

This hazy region contains the atmosphere and ionosphere of Mars

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Happy Fourth of July!
Mars in context

Let’s focus here

0.5 x R-Earth

Carbon dioxide atmosphere

1.5 AU from Sun

100x smaller surface pressure

Same rotation rate as Earth and target of many spacecraft in last 15 years

www.nineplanets.org
The ionosphere of Mars

Neutral atmosphere is mainly CO$_2$, O becomes significant at high altitudes

O$_2^+$ is main ion at all altitudes

EUV photons (10-100 nm) responsible for main M2 layer

Soft X-ray photons (1-10 nm) and secondary ionization responsible for lower M1 layer

Transport only important in topside ionosphere

Withers (2010)
How does the system work?
Chemistry, dynamics, energetics

• Lots of data:
  Plasma vertical structure
  Neutral vertical structure

• Limited data:
  Ion and neutral composition, dynamics, and energetics
  Solar photon, charged particle, magnetic inputs

Withers et al. (2008); Withers and Catling (2010)
Solar control

- Solar zenith angle dependence
  - $N \alpha \cos(SZA)^{-0.5}$
  - Both layers
  Fallows and Withers (2013, sub)

- Solar flux dependence
  - $N \alpha F^{0.5}$
  - Needs good $F$
  Girazian and Withers (2013)
Mars is magnetically crazy
How does this affect ionosphere?

Earth magnetic field

Mars magnetic field

www.windows2universe.org

Brain (2002)
Magnetic effects

Topside radar sounder data
Mars Express orbit 2359

Strong and vertical field means large densities
Why?

Nielsen et al. (2007)
Future is bright – MAVEN

MAVEN carries:
• Particles and fields package
• UV spectrometer
• Mass spectrometer

to measure:
• Solar forcing
• Conditions in magnetosphere, neutral atmosphere, and ionosphere

Launch in <6 months, reach Mars in September 2014