Sodium in the Lunar Atmosphere

Paul Withers

Journal Club - 26th January 1999

Introduction to the Lunar Atmosphere

- Extremely low densities
- Dominated by gas-surface interactions
- Contaminated Apollo detection of He, Ar
- Terrestrial detection of Na, K
- Short lifetimes of species
- Suprathermal Na, K

Main factors controlling the lunar Na atmosphere

1 - Sources

2 - Sinks

3 - Gas-surface interactions

4 - Transport dynamics

Sources

- Velocity distribution?
- Spatial and temporal variation?
- 1 - Impacts
- 2 - Photon-stimulated desorption
- 3 - Sputtering by solar wind ions
- Not well understood

Sinks

- Photoionization lifetime ~ 15 hours
- Ions unobservable
- Solar wind accelerates 50% into space, 50% back to surface

Gas-Surface Interactions

- Extremely complicated, not well understood
- Step 1 - Atom impacts surface
- Step 2 - Atom adsorbed for a while
- Step 3 - Atom released with …
- ...Random direction
- ...New energy, between its incident energy and surface thermal energy

Transport Dynamics

- Force 1 - Gravity
- Force 2 - Solar radiation pressure...
- ...Anti-sunward force due to scattering of solar photons
- ...Acceleration ~ 2.7 cm s^{-2}
- ...Important for hot atoms at high altitudes
- ...Doppler shift due to atom-Sun motion

Theoretical Overview and Modeling of the Sodium and Potassium Atmospheres of the Moon

William H. Smyth and
M. L. Marconi (1995)

Astrophysical Journal,
443, 371-392

Model

1 - Sources

2 - Sinks

3 - Gas-surface interaction...

4 - Transport dynamics

Gas-Surface Interactions

Atom either sticks forever or bounces at once

Probability of sticking = “Stickiness”

Released in random direction with new energy

$$\frac{E_{out} - E_{in}}{E_{thermal} - E_{in}} = \text{"Accommodation"}$$

Stickiness => number of atoms in atmosphere

Accommodation => velocity distribution

Model = reality?

In Conclusion…

- Model has fit 2 data sets using similar parameters
- Comparison with more and different data sets is needed
- Simplistic sources and gas-surface interactions
- Learn about lunar and Mercurian surfaces