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Sodium velocity maps on Mercury

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Abstract

Sodium atoms in the exosphere of Mercury experience radiation pressure, at levels depending on radial velocity of Mercury. As a result, sodium atoms are accelerated in the anti-sunward direction over the surface of Mercury. The Earthward-pointing component of their velocity is measurable as a Doppler shift of the sodium emission line from the position expected from the Mercury-Earth relative velocity. We have mapped these velocity vectors over the surface of Mercury, expecting that irregularities in the flow could signal the existence of sodium sources or sinks on the surface. Velocity variations in the southern Mercury hemisphere on April 09, 2010 suggested that sodium sources existed there.

1. Introduction

Our first effort to map sodium velocities was to measure the velocities along a spectrograph slit oriented either north-south or east-west on the planet [2]. We expected that the sodium flow would be similar to laminar flow over a sphere to first order. An example of the results is shown in Figure 1

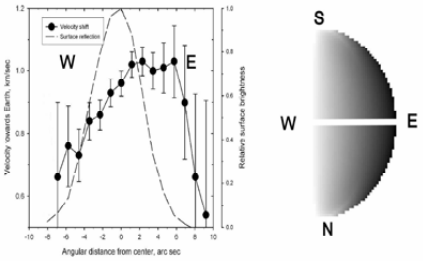

Figure 1: Earthward sodium velocities in an equatorial transect.

For laminar flow over a sphere, the Earthward velocity pattern would be similar to the observed pattern, although the observed velocities near the subsolar point are relatively higher than expected from the laminar flow model. This could be the result of source processes near the subsolar point. The objective of the current work was to measure two-dimensional maps of sodium velocities on the Mercury surface and examine the maps for evidence of sources or sinks of sodium on the surface

2. Observations

The McMath-Pierce Solar Telescope and the Stellar Spectrograph were used to measure line spectra at a spectral sample spacing of 7 milliangstroms during each day over the period October 5-9, 2010. The dawn terminator was in view during that time. A series of spectra were taken for which the spectrograph slit was stepped across the planet in 1 arc second intervals. The position of Mercury was stabilized by a 37-actuator adaptive optics system.
The shift of the centroid of the Mercury emission line was measured relative to the solar sodium Fraunhofer line corrected for radial velocity of the Earth. The difference between the observed and calculated velocity shift was taken to be the velocity vector of the sodium relative to Earth. Each line spectrum yielded a line of velocities similar to that shown in Figure 1. The collection of spectra and velocity lines were assembled to yield images of surface reflection, sodium emission intensities, and Earthward velocities over the surface of Mercury. The results are shown in Figures 2 and 3.

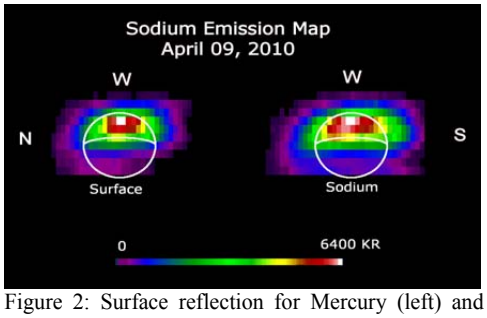

Figure 2: Surface reflection for Mercury (left) and sodium intensity (right) observed on April 9, 2010.

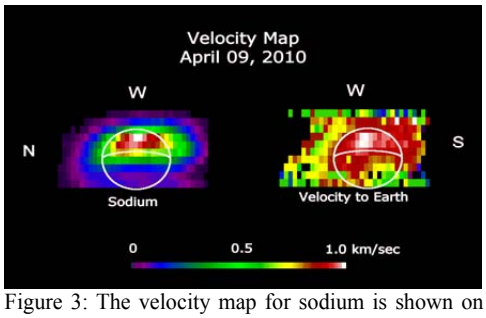

Figure 3: The velocity map for sodium is shown on the right. Relatively higher velocities are seen in south polar regions, suggesting the presence of a source there.

3. Summary and Conclusions

The velocity maps measured in April 2010 show extensive areas of relatively higher velocities in the southern hemisphere, evidence for the existence of additional sodium sources there. Leblanc *et al.* [1] have published a velocity map showing a similar velocity anomaly in the south polar region. The subearth latitude for this work was at -3.9 degrees, partially exposing the south polar region. However, the latitude for the Leblanc observation was nearly opposite at +3.3 degrees, suggesting that the south polar excess was real, and not an effect of the point of view.

Acknowledgements

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