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Spectral Imaging of Io's Neutral Cloud Source Region using AEOS

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Abstract

Jupiter's volcanic moon Io is the primary source of the heavy ions in Jupiter's magnetosphere. Gases from Io's volcanoes (sulphur dioxide with traces of NaCl) form a tenuous atmosphere around Io, and these atmospheric molecules are dissociated, ionized, and ejected from Io via collisions with plasma in Jupiter's magnetosphere. Molecules and atoms which are ejected from Io as neutrals form extended neutral clouds near Io and around Jupiter, and the morphologies of these neutral clouds can be used to infer details of the interaction between Io's atmosphere and the plasma in Jupiter's magnetosphere.

Despite observations of Io's lower atmosphere and of the large-scale neutral clouds, the intermediate "interaction region" where the plasma torus interacts with the atmosphere has been difficult to capture. Global maps of Io's patchy atmosphere have been made during spacecraft encounters and by groundbased observations of mutual eclipses between Io and other satellites. On a much larger spatial scale, the neutral clouds formed by Io's atmospheric escape have been well characterized by groundbased observations. In the intermediate region encompassing Io's upper atmosphere and neutral cloud source region, emission from neutrals is too close to Io for most groundbased telescopes to resolve from Io's disk. It is also a difficult target for spacecraft, as the Galileo orbiter managed to glimpse this intermediate region only once. (Burger et al. 1999)

In May 2006 we used the adaptive optics capability of the Air Force's 3.67-meter Advanced Electro-Optical System (AEOS) to spatially resolve the emission from escaping sodium atoms near Io. We obtained spectral images of the sodium using our own 20x20 fibre optic image slicer and medium-resolution spectrograph. Two features are seen in the data. (1) In all of the images we see a spatially uniform corona of sodium around Io, which is consistent with the "banana" cloud source region. (2) At Io orbital phases near 45 degrees, a second, smaller region of emission is seen extending either ahead of Io or in the anti-Jupiter direction. This appears to be the source region of the $NaCl^+$ stream feature.

We interpret the observed orbital phase-dependent asymmetry as solar-powered sublimation of SO_2 frost contaminated with NaCl on Io's Jupiter-facing hemisphere. Coincidentally, the sub-Jovian hemisphere of Io is also the location of the volcano Loki, which may be the dominate source of atmospheric NaCl when it erupts. In 2006 Loki was in the midst of an unusual quiet period, meaning old frost deposits around the volcano may have taken on greater importance as an atmospheric source.

Our results here contradict the observational results of Burger et al. (2001) who measured higher concentrations of sodium over Io's Jupiter-facing hemisphere at all orbital phases. We hypothesize that the volcano Loki was in a more active state during their observations, meaning that newly outgassed sodium in Loki's plume was creating a longitudinal asymmetry of higher amplitude than that observed in the upper atmosphere source region.

References

[1] Burger, M.; Schneider, N.; Wilson, J. (1999) *GRL*, 26, 3333–3336.

[2] Burger, M. et al. (2001) *ApJ.*, 563, 1063-1074.