EPSC Abstracts
Vol. 6, EPSC-DPS2011-1504, 2011
EPSC-DPS Joint Meeting 2011

Post-Eclipse Behaviour Study of Io Sodium Cloud

C. Grava (1), N.M. Schneider (2) and C. Barbieri (1)
(1) Astronomy Department – University of Padua, Italy
(2) LASP - University of Colorado, Boulder, Co, USA
(cesare.grava@unipd.it / Tel: +39-049-827-8250)

Abstract

We report results of a study of true temporal variations in Io's sodium cloud before and after eclipse by Jupiter. The hypothesis we want to test is that the atmosphere partially condenses when the satellite enters Jupiter's shadow, preventing sodium from being released to the cloud in the hours immediately after the reappearance. For this purpose, we undertook observing runs at the italian telescope TNG at La Palma island with the high resolution echelle spectrograph SARG, both before and after eclipse, in the region around the doublet of sodium, the most easily detectable element in Io's neutral cloud from ground-based observatories. We present differences in brightness and column density before and after the eclipse.

1. Scientific Goals

Sodium forms three distinct cloud components around Jupiter's satellite Io, each of which represents a different atmospheric escape mechanism. The most prominent feature is the extended, banana-shaped cloud, composed by escaping atoms with low velocity with respect to Io, thus orbiting with it around Jupiter. While we have an adequate understanding of the big picture of atmospheric escape from Io, it is not known what role its thin atmosphere plays in moderating the supply of sodium to the extended cloud: does it hinder the supply of sodium directly from the surface to the cloud, or does it promote escape by placing so much material at high latitude? With this work we want to test the hypothesis that the exosphere partially condenses during eclipse by Jupiter's shadow, studying the brightness of the sodium neutral cloud and removing its dependence on orbital position.

1.1. The resonant scattering mechanism

Although a minor species in the exosphere of Io, sodium is the most easily detectable element by ground-based observatories, thanks to the high cross section for resonant scattering of solar photons. This effect is described by the so-called γ-factor, the ratio between the solar intensity of the absorption line at a given wavelength and the solar intensity at the continuum. It is an indicator of how much solar light a sodium atom experiences at a given heliocentric velocity. When this is zero (this happens when Io is at conjunctions), atoms experience a very small amount of solar light, corresponding to the bottom of the Fraunhofer line. In this case the γ-factor is 0.05, meaning that the sodium atoms receive 5% of the solar continuum (right side of the Fig. 1). As Io increases the modulus of the heliocentric velocity, the atoms have more light available for scattering and the sodium cloud will be brighter (left side of the Fig. 1): the γ-factor increases up to 0.70 at elongations.

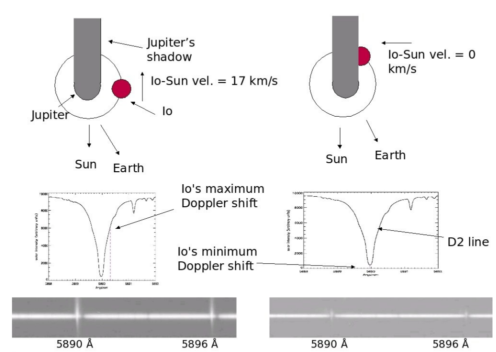

Figure 1: The dependence of sodium cloud brightness on orbital position. Left part: Io is at western elongation; right part: Io is at superior conjunction. Top: geometrical configurations; Middle: plots of solar radiance around the sodium D2 line, to show the dependence of the γ-factor from the orbital longitude; Bottom: the spectra of Io, showing the sodium emission being fainter while Io-Sun relative velocity approaches zero.

1.2. The Condensation Hypothesis

The brightness of the sodium cloud does not depend only upon the γ-factor, but also upon the amount of sodium atoms that scatter sunlight. Some past observations showed some sign that the sodium cloud immediately after the eclipse is less bright than the expected, and reaches the expected values of luminosity hours after the reappearance. One possible explanation is condensation of sulfur dioxide during the eclipse, which would prevent NaCl (principal source of sodium atoms) from being released (see Fig. 2). This is the hypothesis we want to test.

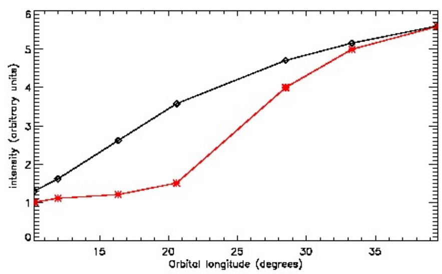

Figure 2: The expected brightness of the neutral sodium cloud. A non-condensing cloud should follow the black diamonds trend; a condensing cloud will follow the red asterisks trend, that is: starting less bright than the expected soon after the reappearance and reaching the purely geometric trend, which depends only by the radial velocity, hours later. The ordinates are brightness in arbitrary units; the abscissae are the orbital longitudes around Jupiter, with 0 degrees meaning superior conjunction, and 90 degrees meaning eastern elongation.

2. Observations

Observations have been carried on 3.6 m italian telescope TNG at La Palma island, equipped with the echelle spectrograph SARG. We aligned the long slit (26.7 x 0.4 arcsec) in the Jupiter-Io direction. We observed Io close enough to Jupiter, both before and after eclipse, and the position of Earth allowed us to look at the neutral cloud nearly perpendicularly, in order to remove line-of-sight effects.

3. Data Reduction

We removed telluric lines using standard stars, then we subtracted Io's continuum using spectra of other satellites. We calibrated Io spectra in Rayleighs ($1\,Rayleigh = 10^6/4\pi \ \ photons\, cm^{-2}\, s^{-1}\, sr^{-1}$) using Jupiter's intrinsic brightness in the region of sodium doublet. Finally, we divided this intrinsic brightness by the γ-factor in order to remove dependence of brightness from heliocentric velocity (and thus from orbital position).

4. Results

We will present differences in brightness and in column density before and after eclipse.

Acknowledgements

This work has been supported by NSF's Planetary Astronomy Program, INAF/TNG and the Astronomy Department of University of Padova, through a contract by the Italian Space Agency ASI.