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Characterization of the ovals in Jupiter's atmosphere using the first data by Juno/JIRAM instrument

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Abstract

Since the first orbits, the Jovian InfraRed Auroral Mapper (JIRAM) aboard the NASA/Juno spacecraft observed several oval vortices in the Jupiter's atmosphere with the highest spatial resolution achieved so far from space-borne infrared instruments. In particular, JIRAM highlighted a line of closely spaced oval features in Jupiter's southern hemisphere, between 30°S and 45°S (Fig. 1), as well as other persistent vortices in the northern hemisphere. The longitudinal region between 120°W and 60°W in System III coordinates covers the three ovals having higher contrast at 5 µm. Using the JIRAM's full spectral capability in the range 2.4-3 µm, which is sensitive to changes in high tropospheric clouds and in stratospheric hazes, as well as to gaseous ammonia, together with a Bayesian data inversion approach we retrieved maps of column densities and altitudes for an NH_3 cloud and a photochemical haze. The deep well-mixed volume mixing ratio and the relative humidity for gaseous ammonia were also retrieved. Our results suggest different vortex activity for the studied ovals. Vertical atmospheric dynamics together with considerations about the ammonia condensation could explain our maps providing evidence of cyclonic and anticyclonic structures.

1. Introduction

The white ovals, together with the Great Red Spot (GRS), are the most prominent features in the Jupiter's atmosphere. They were first observed by ground-based measurements [5], then in more detail during the flybys of Jupiter carried out by the NASA Voyager probes in 1979 and during the extensive in-system tour performed by the NASA Galileo spacecraft in 1995-2003. These ovals are in a stable configuration known as a "Karman vortex street", where anticyclones are staggered with cyclones [8].

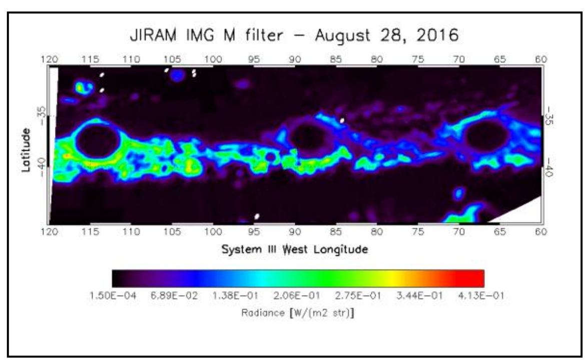

Figure 1: M-filter single image acquired by JIRAM Imager on 28th August 2016, where the three main ovals are clearly visible in the southern hemisphere of Jupiter. Image credits: [7].

The current understanding of the cloud structure in Jupiter's atmosphere is mainly related to theoretical models based on the thermochemical equilibrium models [9, 2]. They predict an ammonia ice layer at about 700 mbar, an ammonium hydrosulfide cloud layer at about 2 bars and a water cloud layer with a base near 6 bars, if the N, S and O elemental abundances are 3x solar . Moreover, observations from the ground and space in the visible, near and thermal infrared provided important information about the aerosol composition of the planet [10, 11]

2. Instrument and Data Set

The JIRAM instrument, aboard the NASA/Juno spacecraft, is composed of an infrared imager (IMG) and a spectrometer (SPE) in the 2-5 μm range [1], sharing a common optical head. The imager is further split in two spectral channels: L-filter, centered at 3.45 μm with a 290 nm bandwidth, and M-filter, centered at 4.78 μm with a 480 nm bandwidth. In this work we used the M-filter of the IMG for the context and the SPE for the characterization analysis. Data we used were acquired during the first orbits of Juno.

3. Method

The retrieval of the atmospheric composition exploits the data inversion technique with the Bayesian approach [6]. It uses the Gauss-Newton iterative procedure to minimize the cost function.
The synthetic spectrum takes into account the multiple scattering, both by molecules and particles, and it is computed using a plane-parallel approximation [4]. Finally, the convergence criterion takes into account the χ^2 minimization.
The *a priori* knowledge of Jupiter's atmosphere is based on the model suggested by [3] and [7].

4. Conclusions and Future Work

The JIRAM measurements acquired during the first orbit of Juno around Jupiter highlighted the presence of several ovals. The preliminary analysis we performed on the three ovals (Oval#1, Oval#2 and Oval#3) showing the higher contrast in the M band (around 5 μm) using the JIRAM's full spectral capability in the range 2.4-3 μm allowed to infer about their dynamic nature. Indeed, the application of a data inversion algorithm based on a Bayesian approach provided information about the atmospheric structure inside and outside the oval vortices. As a result of our retrieval we produced maps for the column densities and the altitudes of a tholin-coated NH_3 cloud and of a photochemical haze. Moreover, we mapped also the gaseous ammonia deep mixing ratio (below the expected saturation level) and its relative "humidity".
The results here reported are the first obtained from JIRAM observations and therefore should be regarded as preliminary. Simultaneous analysis of solar and thermal dominated spectral range, as well as the extension to other interesting atmospheric features, could provide important insights into the cloud structure and the gaseous content of Jupiter's atmosphere.

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