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Radiative Transfer Modeling of Jupiter's Hot Spots with Keck 5-µm and HST UVIS Observations

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Abstract

We present radiative transfer analysis of several hot spots and ammonia plumes observed in Jupiter's Northern Equatorial Belt in 2017 with both HST WFC3/UVIS and Keck NIRSPEC at 5-µm. We find temperature and gas abundance measurements that help characterize the variance in these properties both within this dataset and in comparison with previous studies of these atmospheric features in Jupiter's NEB and SEB.

1. Hot Spots on Jupiter

Hot spots are primarily located in the North (NEB) and South (SEB) Equatorial Belts, and feature radiances up to 70 times greater than their surroundings, owing to a combination low cloud opacities and low ammonia abundances [1,2]. This combination of properties also make it feasible to accurately probe the deeper atmospheric layers, which are normally obscured by an opaque ammonia-ice cloud at ∼0.8 bar. Bjoraker et al. [3] used 5-µm spectroscopy and radiative transfer modeling of an SEB hot spot to identify cloud layers, vertical structure, and chemical composition down to 4-5 bar. The hot spots and ammonia plumes are caused by the equatorially trapped Rossby wave. We use radiative transfer modeling in the UV, visible and 5-µm wavelength ranges to examine the temperature and ammonia abundance variations in a selection of hot spots and ammonia plumes observed in and just south of the NEB in January 2017 (See Fig 1, 2).

2. SUNBEAR Radiative Transfer

We use an in-house radiative transfer program called SUNBEAR [4], a python program based on the pydisort module [5]. In addition to performing the radiative transfer modeling, SUNBEAR performs atmospheric retrieval using Markov Chain Monte Carlo simulations via the python module emcee. SUNBEAR has previously been used to model Uranus at IR wavelengths [6], and Neptune and Jupiter at UV, Visible, and IR wavelengths [4,6,7]. Further details on the code can be found in Appendix A of [4]. We use this program to model the propagation of both reflected solar light and thermal emission, which constrains gas abundances and structure, cloud depth, and temperature.

3. 5-µm Spectra and HST Images

We obtained simultaneous HST WFC3/UVIS imaging and NIRSPEC spectroscopy on the Keck telescope in January 2017. HST images are in multiple filters, covering wavelengths from ∼200-900 nm, while the NIRSPEC spectroscopy covers the 5-µm range. HST WFC3/UVIS images are sensitive to high altitude aerosols and clouds down to the first opaque cloud layer (typically ∼0.8 bar, but deeper in hot spots), while the 5-µm spectra are sensitive to the deeper cloud layers, temperature, and gas abundances, including ammonia (typically down to ∼4-5 bar). Additionally, high resolution HST imaging gives a clear view of nearby atmospheric features, which provides useful context to spectroscopic observations. The dataset contains a host of atmospheric features including NEB hot spots, plumes, vortices, and an outbreak event in the SEB. The last feature was examined in the visible and at 5-µm using SUNBEAR. These data were presented in [7], which presents a suite of multiwavelength observations from January 2017. We use SUNBEAR to examine the UV/visible and 5-µm spectra of a collection of hot spots and ammonia plumes identified in and near Jupiter's NEB.

4. Figures

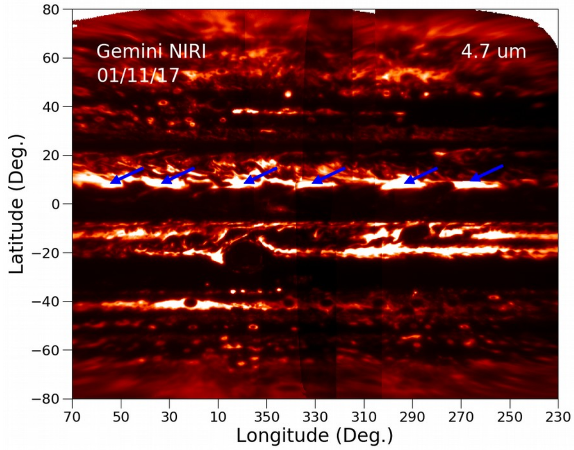

Figure 1: Gemini 4.7-μm image of Jupiter from Jan 11th, 2017. Hot spots are indicated with blue arrows. Adapted from [7].

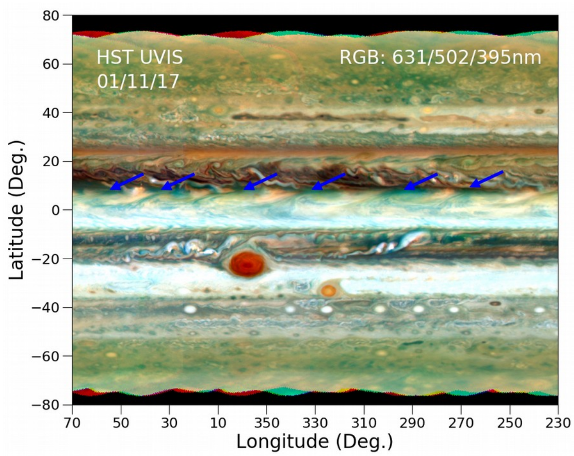

Figure 2: HST color mosaic of Jupiter from Jan 11th, 2017. Hot spots are indicated with blue arrows. Adapted from [7].

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