Temporal evolution of the color of Jupiter's storm Oval BA

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Introduction

Jupiter's storm Oval BA has undergone several storm-wide color changes since its formation between 1998 - 2000. Having a better interpretation of the mechanisms powering these color changes could provide a deeper understanding to similar processes observed in other storms on Jupiter. In this work, we characterize the optical and very near-infrared spectrum of Oval BA in its reddened state in 2015 and its re-whitened state in 2019.

We use three datasets of Oval BA from two different times to study the color change, two from the Outer Planet Atmospheres Legacy (OPAL) program and one from the NMSU Acousto-Optic Imaging Camera (NAIC). The first OPAL dataset is from 2015 and captures a reddened Oval BA while the other OPAL dataset and the NAIC dataset are from 2019 and capture a re-whitened Oval BA. This comparison of Oval BA at different colors will help us understand the nature of the coloring agent and how it is manifested in Oval BA and other storms on Jupiter.

History of Oval BA

- Formed between 1998-2000 from 3 white anti-cyclonic storms in Jupiter's South Temperate Belt (Simon-Miller et al., 2006)
- Formed as a white storm, then dramatically reddened in late 2005 (Simon-Miller et al., 2006)
- In 2008, Oval BA began gradually lightening from red back to white (Hueso et al., 2009)

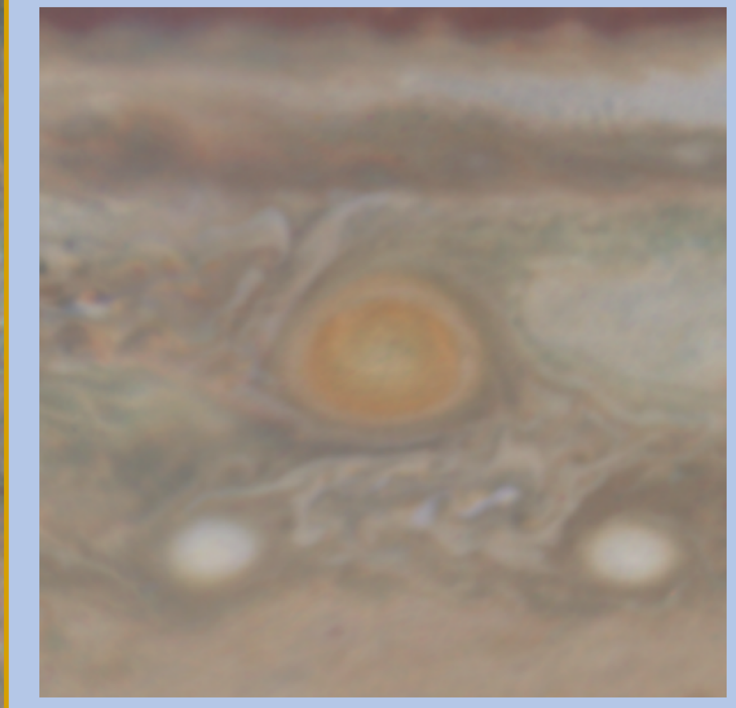

Figure 1: Oval BA from OPAL data using the Hubble Space Telescope in 2015. Here, Oval BA is still noticeably red with a lighter center surrounded by a darker collar.

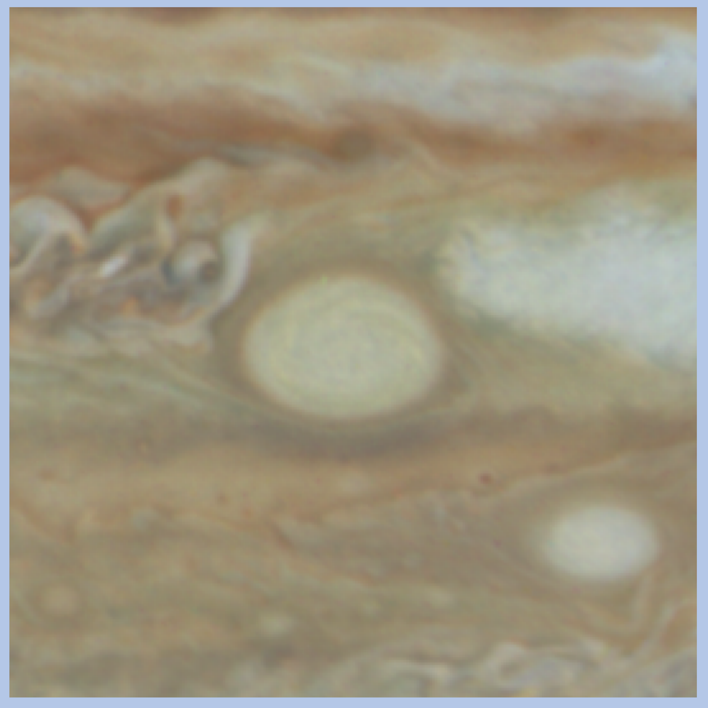

Figure 2: Oval BA from OPAL data in 2019 showing a significantly whiter Oval BA.

Acknowledgments:
This work used data acquired from the NASA/ESA HST Space Telescope, associated with OPAL program (PI: Simon, GO13937), and archived by the Space Telescope Science Institute, which is operated by the Association of Universities for Research in Astronomy, Inc., under NASA contract NAS 5-26555. All maps are available at http://dx.doi.org/10.17909/T9G593.

References:

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Observations

- Observations were made using the NAIC instrument on the Astrophysical Research Consortium's (ARC) 3.5-meter telescope at Apache Point Observatory (APO) in Sunspot, NM
- NAIC uses an acousto-optic tunable filter (AOTF) as the filtering element to produce hyperspectral image cubes of Jupiter
- Image cubes span 470 – 950 nm with images being taken every 2 nm
- Image cubes were taken in support of the Juno mission, providing a higher resolution spectral complement to Juno's few, broad filters
- The observations used in this work were taken on the night of May 27, 2019, which corresponds to the 20th perijove pass made by Juno
- The raw data were processed using the NAIC data pipeline, which includes standard CCD data reduction steps, steps unique to an acousto-optic instrument, photometric calibration using standard A0V stars observed on the same night, and a spectral leakage correction due to the NAIC filters letting in extra light from the continuum through their side lobes
- The data pipeline returns a calibrated data cube, from which an I/F, or absolute reflectivity, spectrum of Oval BA in its 2019 re-whitened state was extracted

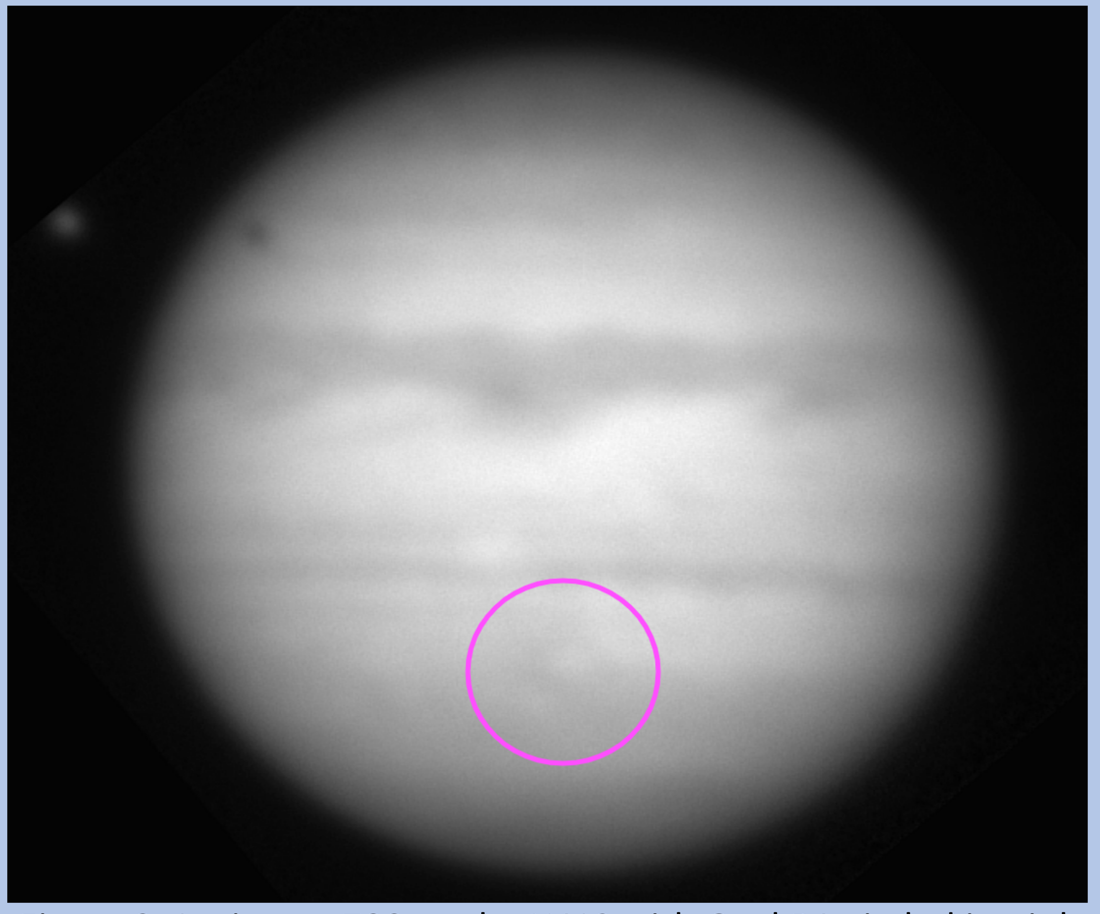

Figure 3: Jupiter at 788 nm by NAIC with Oval BA circled in pink.

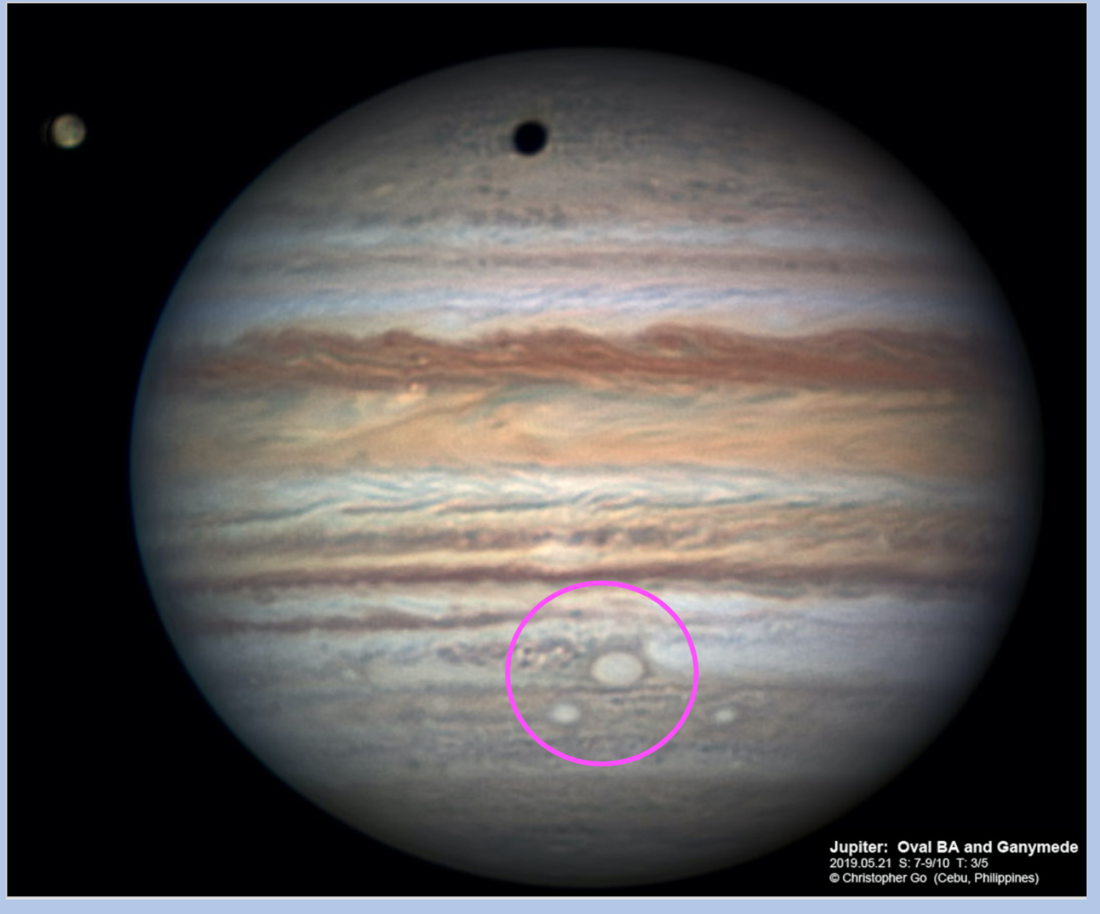

Figure 4: Image of Jupiter by Christopher Go on May 21, 2019 with Oval BA circled in pink, downloaded from the Planetary Virtual Observatory & Laboratory (Hueso et al., 2010). This confirms that the storm we see in the NAIC image is Oval BA.

Results

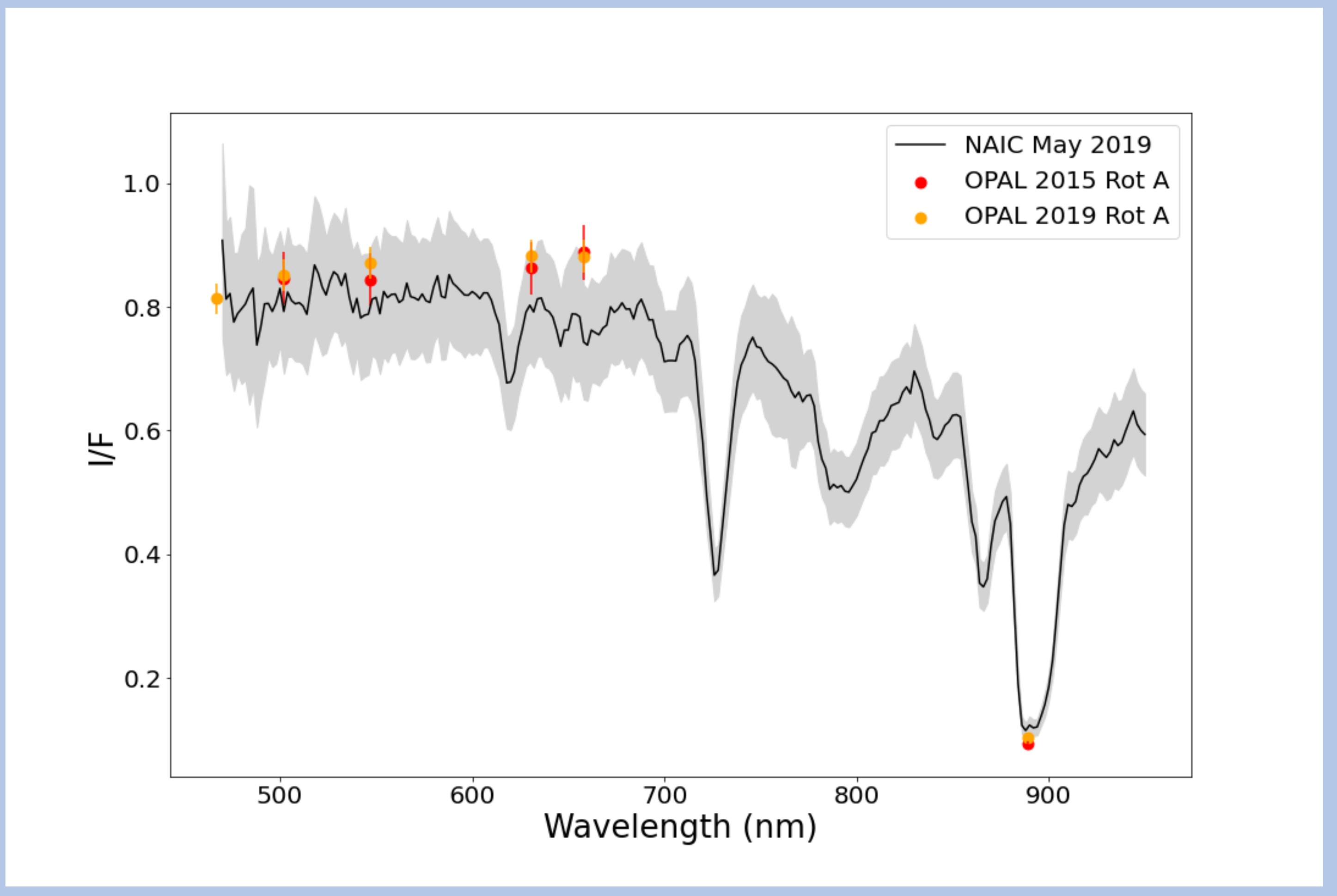

Figure 5: NAIC 2019 spectrum of the re-whitened Oval BA compared with two spectra from OPAL, one from 2019 as well and the other from the redder Oval BA in 2015.

Error bars for the OPAL data were generated assuming 5% error, chosen to match the assumed uncertainty described in Pérez-Hoyos et al. 2009. In the OPAL data, two full rotations of Jupiter are acquired per Hubble Space Telescope cycle (Simon et al., 2015). Rotation A was chosen for both OPAL spectra as it included more data within the NAIC wavelength range, making a more useful comparison to NAIC data.

Discussion

None of the three spectra presented in figure 5 significantly differ from each other. This is unexpected as there is a visible difference in color between Oval BA in 2015 and Oval BA in 2019, as shown in figures 1 and 2.

One limitation of the NAIC data is that it does not extend beyond 470 nm, therefore eliminating blue wavelengths where effects of the chromophore would be most noticeable. At wavelengths bluer than 500 nm, the chromophore responsible for reddening on Jupiter becomes much more absorbent (Carlson et al., 2016). Not having access to these blue wavelengths in the NAIC data could be the reason that we do not see any significant difference between the different spectra.

Future work will investigate whether the spatial regions from which we are extracting the different spectra from are truly identical between data and achieve finer time steps by extracting spectra of Oval BA from all OPAL data and NAIC data possible.