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Identifying the source of colour and featural changes in Jupiter's atmosphere from MUSE/VLT

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Abstract

MUSE/VLT observations of Jupiter have been made in the visible/near-IR (0.48-0.93μm) at high spectral resolution between 2014-2017, providing global context to Juno observations in the mid-IR and microwave, and enabling cloud structure and colour to be better constrained at the level of the visible cloud layers. Significant changes were observed in the appearance of the northern hemisphere of Jupiter in 2017. Changes in cloud structure were modelled using the 'Crème Brûlée' model of Sromovsky et al [5], and using the chromophore of Carlson et al [2] as the main blue-absorber. This model was seen to fit the belt regions of Jupiter well, indicating a predominantly high-altitude source of cloud colour, but a poor fit was seen with respect to the zones due to excessive green-absorption.

1. Introduction

Significant changes in colour and in the general appearance of discrete features on Jupiter have been observed in the past few years, particularly in the northern hemisphere and the Great Red Spot, which is observed to have shrunk in longitudinal size and become redder since 2012 [4]. We attempt to quantify these changes using the MUSE integral-field spectrograph [1], providing comprehensive wavelength coverage in the visible/near-IR (0.48-0.93μm), and providing global context to Juno observations in the mid-IR and microwave, in order to further constrain vertical cloud structure at the level of the visible cloud layers, as well as the composition of the 'chromophore' particles that colour Jupiter's belts and Great Red Spot.

2. Modelling and preliminary results

Our data consists of five sets of MUSE spectral image cubes between February 2014 and March 2017. The most noticeable change in Jupiter's appearance is in 2017, when the northern boundary of the North Tropical Zone appears to move southwards, followed by an increase in high-altitude haze, as shown in Figure 1. Our retrievals confirm that the narrowing of the North Tropical Zone is accompanied by a local decrease in tropospheric cloud opacity and an increase in opacity of the chromophore layer, as shown in Figure 2, but this also appears to be accompanied by a reduction in the tropospheric cloud opacity of the Equatorial Zone.

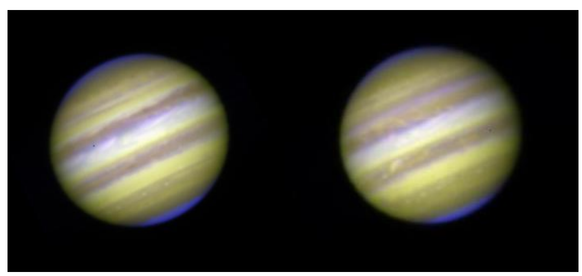

Figure 1: MUSE False colour image of Jupiter in (*left*) 9th March 2016, (*right*) 10th January 2017. Regions that are bright at 0.89μm are shown in blue

We attempt to replicate the results of Sromovsky et al [5] by modelling a meridional swath of Jupiter's atmosphere using the 'Crème Brûlée' model, consisting of a high-altitude stratospheric haze layer and a thin layer of chromophore with the optical constants of Carlson et al [2] just above an extended tropospheric cloud layer. We find this model generally provides a good fit to the MUSE data in the belt regions, indicating a stratospheric source of colour on Jupiter. However, contrary to the findings of Sromovsky et al, we find that the imaginary refractive index of the chromophore must be significantly reduced at green wavelengths to provide a good fit in the zones.

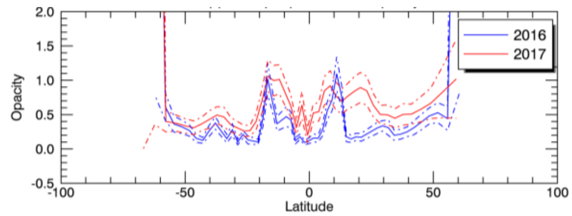

Figure 2: Retrieved change in chromophore opacity along a central meridian of Jupiter between 2016 and 2017

Summary and Conclusions

We use visible/near-IR spectra from MUSE/VLT to constrain cloud structure and colour in Jupiter's troposphere at high spectral resolution, thereby providing global context to localised Juno observations. Significant changes in appearance and cloud structure are observed in the northern hemisphere of Jupiter. We are generally able to provide a good fit to the MUSE spectra using Sromovsky et al's 'Crème Brûlée' model, although we find that the zones of Jupiter are not green-absorbing enough for Carlson et al's chromophore to be a good fit there. Irradiated NH_4SH is unlikely to be the main source of colour in Jupiter's atmosphere, as hypothesised by Loeffler et al [3], due to the absence of 0.6μm absorption and a sufficiently large blue-absorption gradient. However, we cannot entirely discount it as a contributor to Jovian colour, perhaps mixed in with the Carlson chromophore layer or in a layer directly below, and we wish to investigate this possibility further in the future once optical constant data become available. We are set to obtain more MUSE observations of Jupiter as the year progresses, and using the aforementioned 'Crème Brûlée' model we wish to further model changes in Jupiter's general appearance, as well as the appearance of the Great Red Spot and other discrete features in Jupiter's atmosphere.

References

[1] Bacon, R., Accardo, M., Adjali, L., Anwand, H., Bauer, S., Biswas, I., Blaizot, J., Boudon, D., Brau-Nogue, S., Brinchmann, J. and Caillier, P.: The MUSE Second-Generation VLT Instrument, SPIE Astronomical Telescopes + Instrumentation, pp. 773508-773508, 2010.

[2] Carlson, R. W., Baines, K. H., Anderson, M. S., Filacchione, G., and Simon, A. A.: Chromophores from Photolyzed Ammonia Reacting with Acetylene: Application to Jupiter's Great Red Spot, Icarus, Vol. 274, pp. 106-115, 2016.

[3] Loeffler, M. J., Hudson, R. L., Chanover, N. J., and Simon, A. A.: The spectrum of Jupiter's Great Red Spot: The case for ammonium hydrosulfide (NH 4 SH), Icarus, Vol. 271, pp. 265-268, 2016.

[4] Simon, A. A., Wong, M. H., Rogers, J. H., Orton, G. S., De Pater, I., Asay-Davis, X. , Carlson, R.W., and Marcus, P. S.: Dramatic Change in Jupiter's Great Red Spot from Spacecraft Observations, The Astrophysical Journal Letters, Vol. 797, L31, 2014.

[5] Sromovsky, L. A., Baines, K. H., Fry, P. M., and Carlson, R. W.: A Possibly Universal Red Chromophore for Modeling Color Variations on Jupiter, Icarus, Vol. 291, pp. 232-244, 2017.