

DYNAMICS AND CLOUDS IN JUPITER EQUATORIAL ZONE

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Abstract

In this work we show a study of the dynamics and clouds in the equatorial zone of Jupiter. The studied area is wider than the pure Equatorial Zone (EZ) ranging from the southern limit of the South Equatorial Belt (SEB) to the northern limit of the North Equatorial Belt (NEB).

We have used images from the Cassini flyby in December 2000 (wavelengths of 752 and 939 nm) and from the Galileo orbiter taken in 1999 and 2001 (wavelengths of 559 and 756 nm). When needed we have used images from the International Outer Planet Watch (IOPW) database to complete the time coverage of the dataset.

In visible wavelengths the study of the dark-bluish regions in the northern limit of the NEB that corresponds to the infrared (IR) “hot spots” show that they have the characteristics of a Rossby wave and can be explained as some Rossby wave induced effect. Nevertheless trying to explain the smaller and more abundant dark marks situated on the southern limit of the SEB in the same way has proven to be much more difficult. We will describe too our measurements of an anticyclonic white oval situated near the SEB dark marks.

Finally we will present three train gravity waves that we have found in Galileo maps near the Equator.

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1 Zonal and meridional wind profiles

As a reference we have determined the zonal and meridional velocity profiles of this region in each year. We have used both 2D correlation techniques and manual tracking of features to determine the velocity map of the target area. The mean results are shown in Fig. 1.

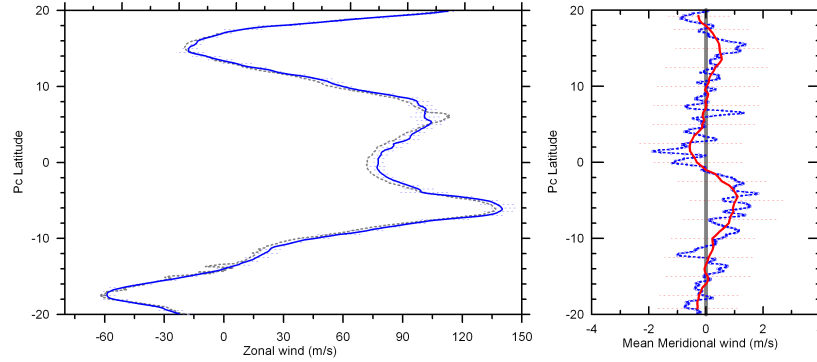


Fig. 1. Zonal and meridional wind profiles on Jupiter equatorial zone

The zonal wind profile at cloud level is very similar to previously known profiles [1] showing no significant differences. The meridional wind values are at the images resolution limit but they are never higher than 2 ms^{-1} .

2 Hot spots

Near 8° N IR images show some 10-12 warm ($T \approx 350 \text{ K}$) patches that in integral light appear dark-bluish (dark projections) as shown in Fig. 2. These “hot spots” are currently interpreted as regions of reduced cloud coverage.

The continuous tracking of individual dark projections allowed us to identify some clues of their movement. Stand out the discovery of some dark projections moving with a common velocity, forming groups or families. But this only happens in some years. This behaviour can be explained as a result of Rossby waves dispersion.

From our measurements of the movement of the different dark projection groups we obtained the dispersion relationship shown in Fig. 3

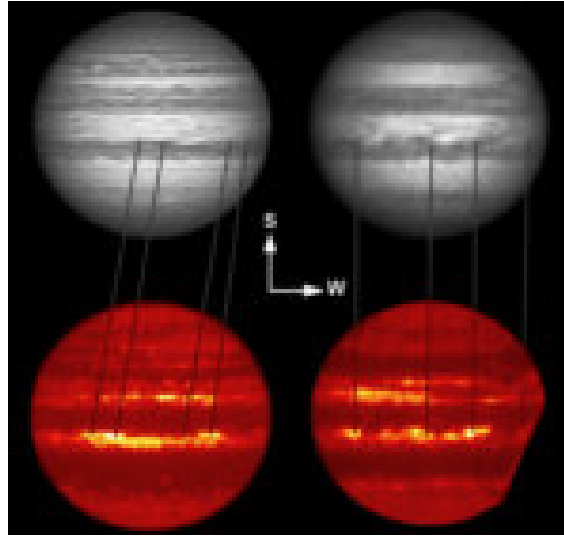


Fig. 2. In the top row appear the dark projections in integral light images. In the bottom row appear near simultaneous IR ($4.8 \mu\text{m}$) images. The lines show the correspondence between marks.

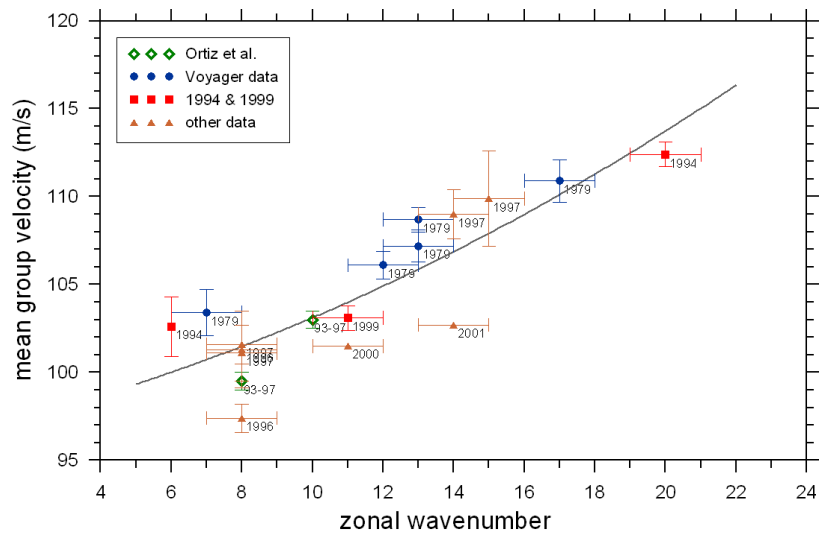


Fig. 3. Experimental dispersion relationship of the dark projection groups.

Theoric interpretation follows the linear wave model developed by Allison [2]. The dispersion relationship for a Rossby wave that he obtains is:

$$c - \langle u \rangle = \frac{-\frac{\beta \cdot R_p^2}{n^2}}{1 + (2j+1) \frac{\beta \cdot R_p^2}{n^2 \sqrt{gh}}}$$

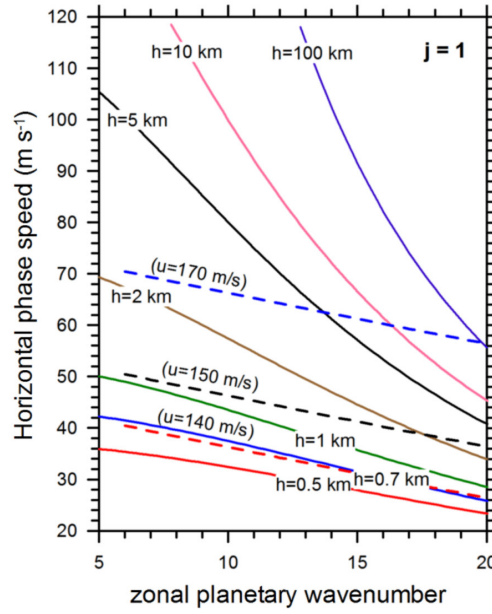


Fig. 4. Discontinuous lines show the experimental measurements shifted by the zonal flow at some height in Jupiter 's atmosphere. Continuous lines represents Allison's model dispersion relationship.

Fig 4 shows the experimental results from our study of the movement of the dark projection families plotted versus the predictions of the dispersion relationship in the Allison's model. The best fit is found when the Rossby wave is shifted by a zonal flow velocity of 140 ms^{-1} and the equivalent height for the wave is $h = 0,7 \text{ km}$ [3]. Interestingly these values are similar to the ones that Ortiz et al. [4] found when studying the hot spots movement in the IR.

After this we tried to apply the same interpretation to the symmetrical marks appearing in the southern limit of the SEB (7° S). They are as many as 70 and

smaller than the dark projections in the NEB. This time we have not found any grouping and they are considered a unique group, so we are dealing with a wavenumber of 70. When we put into the dispersion relationship this value and the mean motion of $134 \text{ m}\cdot\text{s}^{-1}$ we are faced to the fact that in this region of the plot there is not enough resolution to extract a valuable conclusion because for such a high wavenumber the different plots converge.

3 SEB white oval

The centroide of this white oval is located at 5.5° S , so that the lower tip plunges into the SEB dark projections latitude band. The velocity of the centroide as measured by us is 88 ms^{-1} whereas the mean velocity of the dark projections is 134 ms^{-1} . After measuring the velocity vectors of some points in the periphery of the oval we have obtained a net vorticity value as shown in Fig.5.

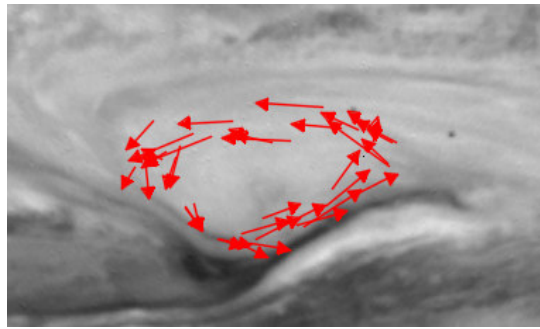


Fig. 5. The white oval in the SEB.

4 Gravity waves

In the higher resolution maps obtained from the Galileo orbiter images we have found three train waves near the equator aligned with N-S direction. Their characteristics suggest that they are gravity waves (see Fig. 6).

For gravity waves a simple linear model [5] gives us the following dispersion relationship:

$$c - \langle u \rangle = \pm \frac{N}{\sqrt{k^2 + m^2}}$$

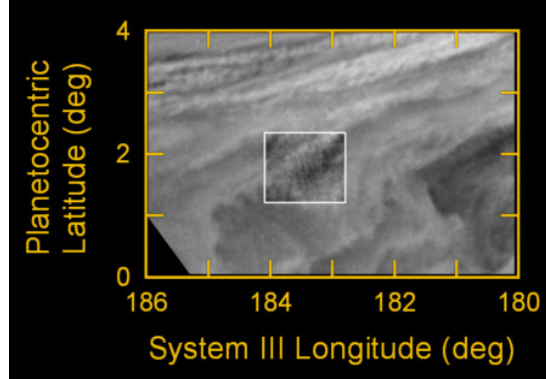


Fig. 6. Gravity waves near Jupiter's equator.

In Fig. 7 the retrieved values are plotted versus the linear model, supposing that these waves happen in a tropospheric level with a Brünt-Vaisäla frequency of $5 \cdot 10^{-3} \text{ s}^{-1}$, typical of the cloud level.

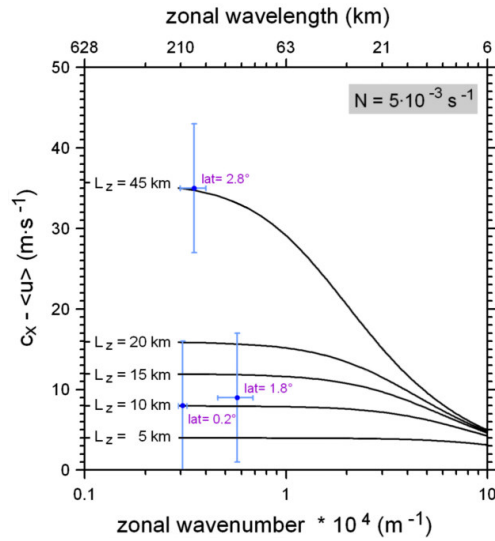


Fig. 7. Gravity waves experimental values and dispersion curves.

References

- 1 Porco, C. C., et al., Cassini Imaging of Jupiter's atmosphere, satellites and rings
- 2 Allison, M., Planetary waves in Jupiter's equatorial atmosphere, *Icarus*, 83, 282-307, 1990.
- 3 Arregi, J., Rojas, J. F., Sánchez-Lavega, A., Morgado, A., Phase dispersion relation of the 5-micron hot spot wave from a long-term study of Jupiter in the visible, *Journal of Geophysical Research*, 111, E09010, 2006.
- 4 Ortiz, J. L., Orton, G. S., Friedson, A. J., Stewart, S. T., Fisher, B. M., Spencer, J. R., Evolution and persistence of 5-microns hot spots at the Galileo Probe entry latitude, *Journal of Geophysical Research*, 103, 23051-23069, 1998.
- 5 Salby, M. L., Fundamentals of atmospheric physics. International Geophysics Series. Academic Press. 1996.