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Torsional oscillations in Jupiter and their link to tropospheric variability

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Jupiter's weather layer exhibits long-term and quasi-periodic cycles of meteorological activity [e.g. 1]. There are cycles with intervals from 4 to 9 years, dependent on the latitude, detected in infrared radiation [2], which provides a window into the cloud-forming regions of the troposphere. The origin of these cycles, however, has been a mystery.

Meanwhile, the NASA Juno mission has revealed that the zonal jets extend down below the surface [3], and has yielded the high resolution JRM model of Jupiter's internal magnetic field [4].

Here we propose that tropospheric dynamics at mid-latitudes is triggered differently from that in the equatorial region, and demonstrate that the quasi-periodic variability at the mid-latitude could be explained by torsional Alfvén waves, or torsional oscillations [5], arising from the deep dynamo region of the gas giant [6]. These axisymmetric waves are magnetohydrodynamic (MHD) waves influenced by the rapid rotation, and to date they have only been evidenced in Earth's core [7].

Using the magnetic field model JRM, together with the density distribution model, we compute the expected speed of these waves. For the wave excited by variations in the zonal jet flows, their wavelength can be estimated from the width of the alternating jets, yielding waves with a half period of several years at mid latitudes, consistent with intervals identified in the infrared observations.

The nature of these waves is revealed by a data-driven technique, dynamic mode decomposition [8,9], applied to the spatio-temporal data for the infrared emission. The wave speed found in the data agrees approximately with the expected speed of the torsional waves.

Our results imply that exploration of these MHD waves may provide a new window to the internal dynamics and an astrophysical dynamo.

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