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Comparison between the deep atmospheric dynamics of Jupiter and Saturn in light of the Juno and Cassini gravity measurements

Yohai Kaspi and Eli Galanti
Weizmann Institute of Science, Earth and Planetray Sciences, Rehovot, Israel (yohai.kaspi@weizmann.ac.il)

Jupiter and Saturn both exhibit strong zonal flows at the cloud level. Jupiter's flows consist of strong latitudinally alternating east-west zonal jets (up to 140m/s), with a significant asymmetric component between the northern and southern hemispheres. On Saturn, the wind pattern is a wide and a mostly symmetric eastward flow of more than 400 m/s at the equatorial region, and smaller scale jets extending to high latitudes. How deep these winds penetrate into the planets' interior has remained a fundamental open question until recently, when both Juno at Jupiter and Cassini at Saturn enabled answering this decades long question.

The gravity experiment, performed by both spacecraft, provided measurements of the gravity harmonics with unprecedented accuracy. They brought into light substantial differences between the two planets. The Jupiter's even gravity harmonics were found to follow closely those predicted by rigid body models and its odd harmonics are large, clearly above the measurement uncertainty level. Conversely, the even harmonics of Saturn deviate considerably from those predicted by rigid body models, for all harmonics larger than J4, and its odd harmonics turned out small with only J5 being substantially above the uncertainty level.

Using the gravity measurement, together with an adjoint based inverse model of the flow dynamics, we find that on both planets the winds are very deep - reaching around 3,000km on Jupiter and 9,000km on Saturn. This points to some similarities and differences on both planets. On both planets the winds observed at the cloud level are a manifestation of deep flows extending thousands of kilometers deep, to the level where the electric conductivity is large enough that the flow may be dissipated by the magnetic field. With that, the winds on Saturn, penetrate 3 times deeper and are much more symmetric than the winds on Jupiter. These differences are likely the result of Saturn being 3 times less massive so that the electrical conductivity increases at deeper levels.

In the presentation we will discuss the gravity measurements, the depth of the winds analysis including the best fit vertical wind profile, and the implications to the characteristics of the two planets.