Atmospheric confinement of jet streams on Uranus and Neptune

The observed cloud-level atmospheric circulation on the outer planets of the solar-system is dominated by strong east-west jet streams. The depth extent of these winds is a crucial unknown in constraining their overall dynamics, energetics, and internal structures. There are two approaches to explain the existence of these strong winds: The first suggests that the jets are driven by shallow atmospheric processes near the surface, while the second suggests that the atmospheric dynamics extend deep into the planetary interiors. Here we show, that on Uranus and Neptune, the depth of the atmospheric dynamics can be revealed by the low-order gravity field. We show that the measured fourth order gravity harmonic, J4, constrains the dynamics to the outermost 0.15% of the mass on Uranus and 0.2% on Neptune. These constraints are obtained by placing an upper limit to the difference between the observed J4 and the J4 contribution of a static planet over a wide range of interior structures, and comparing this difference to the dynamical contribution to J4 obtained from models with dynamics. We thus provide a much stronger limitation to the depth of the dynamical atmosphere than previously suggested, and show therefore that the dynamics are confined to a thin weather layer of no more than 1000 km on both planets (Kaspi et al., Nature, 2013).

For Jupiter and Saturn, more accurate gravity data is required to calculate precise limits. This is likely to be obtained in 2016 when the Juno and Cassini spacecraft perform close flybys of these planets, measuring the gravity spectrum at unprecedented precision. While the low order gravity harmonics of Jupiter and Saturn are dominated by the oblateness and radial mass distribution of the planets, the high (n>10) and odd gravity harmonics contain information about the dynamics. We suggest that given the measurement sensitivity, the odd gravity harmonics coming from north-south hemispherical asymmetries in the circulation, will likely give the most information about the deep wind structure on these planets (Kaspi, GRL, 2013).