Saturn's Gravitational Field, Internal Rotation, And Interior Structure

Daanish Maqbool
ASTR630
10th Oct., 2012

The rotation rate of Saturn has recently been the subject of uncertainty[1,2]. It was previously assumed that the rotation period is the same as the radio period inferred from Saturn Kilometric Radiation (SKR) data, but now it is thought that this period corresponds to that of Saturn's inner plasma disk[2]. In light of these developments, a novel method of calculating Saturn's rotation rate, which is independent of radio or magnetic data, has been employed[1]. This method relies on gravitational measurements from Voyager and Cassini spacecraft, and atmospheric wind speeds obtained using visual methods from Voyager data.

Using positional data from the Cassini probe, it was possible to deduce the values of GM_{Saturn} and the gravitational coefficients J_{2n} due to oblateness. These values, combined with an assumed rotation rate and the polar radius, can then be used to define a reference geoid for the gravitational strength experienced by a particle co-rotating with Saturn[1,3]. Another reference isosurface for Saturn can be obtained using the wind velocity on Saturn from Voyager data[4]. This isosurface can be generated using a geostrophic balance of the winds[1,4], and is sensitive to wind velocity and the assumed rotation rate of the planet. The rotation rate that minimizes the error between these two methods to calculate the height of the 100-*mbar* isosurface is then proposed as the true rotation rate of Saturn. The authors then continue to use this and other rotation rates in the equations for hydrostatic equilibrium to arrive at possible equations of state and densities of the Hydrogen-Helium mixture that constitutes Saturn.

One of the striking results of this study[1] is that the centers of mass and figure of Saturn appear to be offset by about 10 *km*. While the cause is unexplained by the authors, I will explore the possibility that the data they have used for the wind velocity has not been fitted or extrapolated correctly. The authors use wind velocity data from Voyager[4], which is given as discrete points, but in their paper[1] it is represented as a continuous line, which suggests that they may have curve fitted the data. I also suspect that the curve-fitted wind velocity does not approach zero at the poles (where data from Voyager is missing). I will attempt to curve fit the original Voyager data again in such a manner that the wind speed approaches zero at the poles. I will then use this wind velocity to generate the required isosurface, which may remove and explain the offset between the centers of mass and figure.

[1]J. D. Anderson, G. Schubert, *Science* **317**, 1384 (2007)
[2]D. A. Gurnett et al., *Science* **316**, 442 (2007)
[3]G. F. Lindal, D. N. Sweetnam, V. R. Eshleman, *Astron. J.* **90**, 1136 (1985)
[4]B. A. Smith et al., *Science* **215**, 504 (1982)