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A clue about Saturn's normal modes from analysis of Cassini's Grand Finale gravity orbits

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Abstract

After more than 13 years spent orbiting about Saturn, the Cassini spacecraft ended its mission on September 15, 2017 with a deliberate plunge into Saturn's atmosphere. In its final phase, the Grand Finale, Cassini provided the most detailed insights on Saturn's rings, atmosphere, and interior. Out of the 22 proximal orbits, six pericenter passes have been devoted to the determination of the gravity field of the planet. Previous determination was carried out by studying the motion of the satellites. Current observations are far more accurate for determining Saturn's gravity field since the spacecraft passes very close to the cloud tops. In addition, the first gravitational measurement of the rings' masses has been made.

During each of the six passes, Cassini was tracked for about 24 hours by the antennas of both NASA's Deep Space Network and ESA's ESTRACK network, providing high quality Doppler measurements at X-band. The RMS noise level is as low as 0.02 mm/sec, at 30 s integration time, which, together with the favorable orbital geometry, allow a good determination of Saturn's gravity field.

The analysis of the Doppler data is complicated by an unexpected non-zonal and/or non-static component of the gravity field. In fact, for a rotating fluid planet in hydrostatic equilibrium, only zonal gravity coefficients are expected. Non-zonal components may arise from different mechanisms. One of the possible explanations is to suppose a time-varying gravity field, related to Saturn's normal modes. The presence of normal modes inside Saturn has already been proved with ring seismology [1, 2], and used to constrain the interior structure of the planet [3].

In general, the inclusion of normal modes in the analysis of the Doppler data allow us to obtain a satisfactory solution. However, the discrimination of the relevant modes is almost impossible due to the limited temporal coverage. The data analysis has shown that different combinations of gravity and/or acoustic modes can be employed to obtain a good fit of the residuals, and many more combinations are surely possible. We report on the analysis of the gravity data by means of several subsets of normal modes to explain the non-zonal component of Saturn's gravity field.

Acknowledgements

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References

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