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Ground-based Doppler Velocimetry: wind measurements in Saturn's atmosphere with UVES/VLT

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Abstract

We will present the latest Doppler wind velocity results of Saturn's zonal flow at cloud level. The study of the planet's global system of winds at the 0.7 bar region, promises to improve the characterization of the equatorial jet and the latitudinal variation of the zonal winds, as well the measurement (and monitorization) of its spatial and temporal variability, achieving a better understanding of the dynamics of Saturn's zonal winds (which Sánchez-Lavega [8] have found to have changed strongly in recent years). Finally, the complementarity with Cassini, has provided an independent set of observations to compare with and help validate the method.

1. Introduction

The UVES/VLT instrument has been used, which simultaneously achieves high spectral resolving power and high spatial resolution, with the aperture aligned perpendicularly to Saturn's rotation axis. In this configuration, spatial information in the East-West direction is preserved in a set of spectra in the direction perpendicular to the dispersion. The technique of Absolute Astronomical Accelerometry (AAA) [1] has been applied to the backscattered solar spectrum, to determine the Doppler shift associated with the zonal circulation, retrieved by our measurements in the visible wavelength range of 480-680 nm. Previously we successfully adapted this Doppler velocimetry technique for measuring winds at Venus cloud tops [4] [5] [6]. Since the AAA technique only allows to compare spectra where the line shifts are within the line width, in fast rotating atmospheres (such as Saturn), the spectra must be compared by pairs from adjacent areas of the disk (adjacent pixels in the slit).

2. Observations

The observations consisted of 4 blocks of 15 exposures of 90 seconds, plus two shorter blocks of 9 exposures, totaling 7.3 hours of telescope time. Despite most of the northern hemisphere was covered by the rings, the aperture has been offset by 1 arcsec in the North-South direction (beginning at the South pole) between consecutive exposures. Saturn's diameter was 17.4 arcsec and the slit aperture was 0.3 x 25 arcsec. The sub-terrestrial point was at -26.1 S. The presence of the rings led to severe order superposition. The dark region between the rings and the disk may not be present, depending on the slit position. On the other hand, defects in the response of the UVES slit in the upper part prevent its use for accurate Doppler measurements such as these. For these reasons, only the central part of the aperture has been considered for the measurements. We obtained the zonal wind as a function of local time for all slit's offset positions, except for the cases with ring overlapping. For that we estimated the ring system keplerian velocity at each pixel position, and then, superposed the planet + rings spectra and adjusted the most spectral lines possible (the residual components were due to planetary contribution, mostly methane and ammonia).

3. Summary and Conclusions

The Doppler velocimetry has proven to be a competitive ground-based method able to derive wind's velocities on Saturn, allowing cross-comparison with cloud-tracked winds from Cassini' ISS images (wavelength bands 752-764 nm and 937-964 nm), and the study of short-term variability. We will separate the spectra planetary contribution from methane (and also ammonia) and study the altitude from its contribution, based on NEMESIS radiative model [10]. Detection of finer latitudinal variations in zonal winds in the future will require precise modeling (radiative transfer model) of the probed level and an improved treatment of methane/ammonia lines and order superposition effects. Nevertheless, our Doppler velocimetry technique stands out as a promising ground-based method for wind monitoring in the giant planets.

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