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Spectroscopic Observations of Uranus and Neptune by the Herschel SPIRE Experiment: Constraints on Global-Mean Temperature Structure and Composition

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The Herschel SPIRE Fourier Transform Spectrometer (FTS) covers the hitherto relatively unexplored spectral region from 15 to 50 cm^{-1} (200 to 670 μm) with a spectral resolution of 0.048 cm^{-1}. In order to calibrate the instrument we primarily rely on the measurement of the spectrum of Uranus along with corroborating observations of Neptune and other solar system bodies. Accurate models of the spectral emission from Uranus and Neptune are therefore critical to the calibration and interpretation of all SPIRE photometric and spectroscopic data as well as being of significant scientific interest in themselves. In order to probe the sub-millimeter spectrum of Uranus and Neptune as deeply as possible, long disk-averaged spectra of Uranus and Neptune were obtained by the Herschel SPIRE FTS on 7 October 2010 (Herschel Operation Day (OD) 423) and 9 June 2010 (Herschel OD 392), respectively. These observations were made in the context of the investigations of the Herschel Key Project "Water and Related Chemistry in the Solar System". Additional calibration of the instrument response function was derived from observations of the airless Jovian satellite Callisto on 5 January 2011 (Herschel OD 602). For both planets, the continuum in most of this spectral range is controlled by the collision-induced absorption of H_2, and it is sensitive to temperature at atmospheric pressures up to 1.5 bars. Models for their disk-averaged radiances have been derived from measurements of the temperature structure and composition by Voyager, as well as independent observations by the Infrared Space Observatory and the Spitzer Space Telescope at shorter wavelengths, and Herschel PACS measurements of lines of well mixed HD (Lellouch et al. 2010, Astron. & Astrophys., 518, L152). These models will be compared with independent evaluations of the flux calibrated against emission from the Herschel telescope itself, whose temperature is continually monitored, assuming a wavelength-dependent emissivity based on measurements obtained before launch (Fischer et al. 2004, Appl. Opt. 43, 3765). At the long wavelength end of the SPIRE FTS, an evaluation will be made of the need for additional opacity sources, such as H_2S or PH_3, aided by supporting ground-based observations in the SPIRE spectral range and longer wavelengths.