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H_2O_2, H_2O and HDO thermal mapping on Mars using TEXES/IRTF and EXES/SOFIA

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Abstract

Ever since the Viking era, hydrogen peroxide has been suggested as a possible oxidizer of the Mars surface [1]. H_2O_2 was first detected in the submillimeter range [2], then regularly monitored, simultaneously with HDO, using high-resolution imaging spectroscopy at 8 µm with TEXES at IRTF [3]. Comparison with the Global Climate Models (GCM) shows that the observations favor the simulations taking into account heterogeneous chemistry [4]. New observations have been performed on H_2O_2 and HDO with TEXES at IRTF in February 2014, and on H_2O and HDO with EXES on SOFIA in April 2014. The latter dataset, obtained near summer solstice, will be used to build a map of D/H on Mars.

1. H_2O_2 observations with TEXES

The detection of hydrogen peroxide on Mars was finally achieved in 2003 using two independent measurements, both performed from the ground. Clancy et al. (2004) first reported the H_2O_2 detection with a disk average mixing ratio of 18 ppb from their submillimeter heterodyne spectroscopy observations performed in September 2003 [2]. One month later, Encrenaz et al. (2004) reported the detection and mapping of H_2O_2 using the TEXES instrument at the IRTF in June 2003, in the 1237 - 1244 cm^{-1} range. The H_2O_2 mixing ratio was found to range between 20 and 40 ppb [2]. The observed H_2O_2 mixing ratios from both datasets were well in agreement with photochemical models, indicating significant variations over the seasonal cycle. Since 2003, the Martian hydrogen peroxide has been regularly monitored using TEXES at the IRTF. The data sets have been compared with simulations by the Global Climate Model developed at LMD-Oxford [4].

Figure 1 shows a summary of the H_2O_2 observations with TEXES. Five campaigns took place between 2001 and 2009 [5]. A new observing run took place in February 2014 (L_s = 32°) and another one is planned for July 2014 (L_s = 155°).

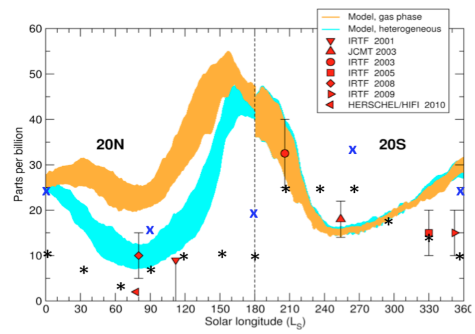

Figure 1*. The seasonal cycle of the H_2O_2 mixing ratio on Mars. TEXES observations refer to 20N latitudes for Ls = 0 - 180° and to 20S latitudes for Ls = 180 - 360°, in order to match as best as possible the observing conditions induced by the axial tip of the planet. GCM simulations ignore (yellow) or include (green) heterogeneous chemistry. Two other GCM simulations are shown in the figure, by Krasnopolsky (2009; black stars) and by Moudden (2007; blue crosses). The figure is taken from [5] and adapted from [4].*

2. HDO Observations with TEXES

Water vapor maps have been retrieved using weak HDO transitions in the vicinity of the H_2O_2 lines, and compared with the GCM. An example is shown in Figure 2 from the data from June 2008, taken shortly before summer solstice (Ls = 80°). The agreement between the data and the GCM is illustrated in Figure 2.

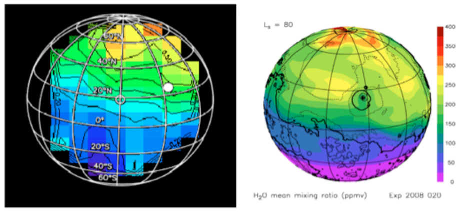

Figure 2. Comparison of TEXES maps and GCM simulations for the June 2008 data set (L_s = 80°). Top: Water vapor mixing ratio (250 ppm at 30N-50N); Bottom: Surface temperatures (maximum values: 245 K). The figure is adapted from Encrenaz et al. (2010).

3. H_2O and HDO observations with EXES on SOFIA

A map of Mars was recorded on April 7, 2014, during the first commissioning flight of EXES aboard the Stratospheric Observatory For Infrared Astronomy (SOFIA), at 1383 - 1391 cm^{-1}. This spectral range contains strong and weak lines of CO_2, H_2O and HDO. The diameter of Mars was 15 arcsec. Data were taken shortly after summer solstice (L_s = 112°), so that water lines are expected to show strong latitudinal variation between their maximum value (at the North) and their minimum value (at the South). Figure 3 shows a mean synthetic spectrum of Mars.

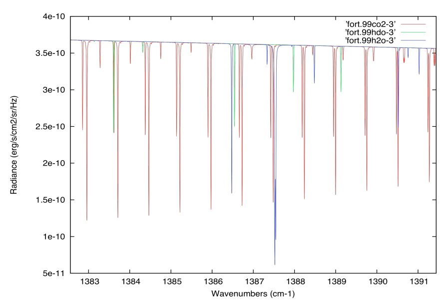

Figure 3. A mean synthetic spectrum of Mars between 1383 and 1391 cm^{-1}. Red: CO_2; blue: H_2O; green: HDO.

Figure 4 shows an echellogram from the map of Mars with the sky subtracted and divided by a blackbody flatfield. The spectral range has about twelve orders that overlap at this wavelength. The double comb of the CO_2 Martian lines are easily visible, as well as the strong telluric water absorption at 1386.5 and 1387.5 cm^{-1} (see Figure 3). H_2O and HDO lines of different intensities will be used to trace the Martian H_2O and HDO abundances from North to South.

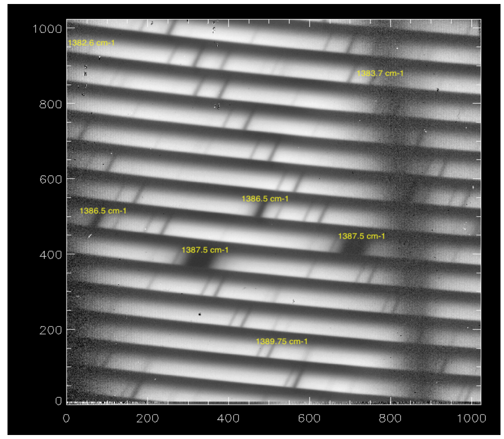

Figure 4. Echellogram extracted from the Mars data. The 1383 - 1391 cm-1 is covered by about 12 orders (from top to bottom). The double structure of strong CO2 Martian lines is visible, as well as strong telluric water absorptions at 1386.5 and 1387.5 cm-1 near the center of the figure.

Acknowledgements

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References

[1] Oyama, V. I. and Berdahl, B. J. J. Geophys. Res. 82, 4669-4676, 1977.
[2] Clancy, R. T., Sandor, B. J., Moriarty-Schieven, G. H. Icarus 168, 116-121, 2004.
[3] Encrenaz, T. et al. Icarus 170, 424-429, 2004.
[4] Lefèvre, F. et al. Nature 454, 971-975, 2008.
[5] Encrenaz, T. et al. Plan. Space Sci. 68, 3-17, 2012.