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Sensitive search of CH_4 on Mars by SOFIA/EXES

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Abstract

We present the results of our sensitive search of CH_4 on Mars using the Echelon-Cross-Echelle Spectrograph (EXES) onboard the Stratospheric Observatory for Infrared Astronomy (SOFIA).

Discovery of CH_4 in the Martian atmosphere has led to much discussion since it could be a signature of biological/geological activities on Mars [1,2,3]. However, the presence of CH_4 and its temporal and spatial variations (0-60 ppb) are under discussion because of the large uncertainties embedded in the previous remote-sensing observations [4]. Although Tunable Laser Spectrometer onboard Curiosity rover detected CH_4 signal and showed strong variability of the amount (0-9 ppb), sensitive remote-sensing observation is still important to search for the source since TLS can measure CH_4 variation only on the Gale crater.

SOFIA/EXES has unique capabilities to perform a sensitive search for CH_4 from Earth. The high altitude of SOFIA (~12-14 km) enables us to significantly reduce the effects of terrestrial atmosphere. Thanks to this, it improves the chance to detect Martian CH_4 lines because it reduces the impact of telluric CH_4 on Martian CH_4, and allows us to use CH_4 lines in the 7.5 μm band which has less contamination.

We performed sensitive measurements of Martian CH_4 by using SOFIA/EXES on 16 March 2016 and 25 January 2017, which corresponds to summer (Ls = 123.2°) and winter (Ls = 305.2°) in the northern hemisphere on Mars (see Table 1). We selected the 1325-1340 cm^{-1} (7.45 - 7.55 μm) interval considering the availability of multiple strong CH_4 lines, and used the high-spectral resolution mode (R~90,000) to improve the possibility of detecting the narrow Martian CH_4 lines. We observed the planet at three separate slit positions (center, right, and left of the Martian disk with an offset of 2.5") on 16 March 2016, and two positions (right and left of the Martian disk with an offset of 1") on 25 January 2017.

We have analyzed the data taken on 16 March 2016 [6]. We confined our analysis to three CH_4 lines at 1327.074219, 1327.409783 and 1332.546743 cm^{-1} because they have no contamination from other lines (i.e., terrestrial CH_4 and H_2O, and Martian CO_2 and H_2O lines) and stronger intensities than the other CH_4 lines. Table 2 summarizes the retrieved CH_4 volume mixing ratios (the weighted averages using the ones retrieved from three CH_4 lines independently), and the corresponding locations (latitude and longitude) and local times. As shown in this Table, there are no definitive detections of CH_4. The Martian disk was spatially resolved into 3 x 3 areas, and the upper limits on the CH_4 volume mixing ratio range from 1 to 6 ppb, which are more stringent than those by the previous remote-sensing observations.

In the presentation, the results from the other data taken on 25 January 2017 will be discussed as well.

Tables

Table 1: Overview of the SOFIA/EXES observations.

Observation Date (UT)	16 March 2016	25 January 2017
Observation Time (UT)	9:59-10:32	1:40-2:11
MY	33	33
Doppler shift (km/s)	-16.2	11.7
Diameter of Mars (″)	10	5.2
Aircraft Altitude (km)	13.7	11.9
Sub Earth longitude (°W)	247-253	347-353
Spectral range (cm^{-1})	1326.57 -1338.66	1325.87 -1337.96

Table 2: CH_4 volume mixing ratio (VMR) on Mars retrieved from the SOFIA/EXES observation carried on 16 March 2016 (Ls = 123.2°) [6]. The Martian disk was spatially resolved into 3 x 3 areas, and the upper limits on the CH_4 volume mixing ratio range from 1 to 6 ppb. Note that EXES spectra were spatially binned over ~2.7 arcsec, which corresponds latitudinal/longitudinal resolution of about ±27° at the sub-Earth point.

Slit position	Lat (°)	East Lon (°)	LT	CH_4 VMR (3σ)
Mars Center #1	-17	179	16	2 ± 3 ppb
Mars Center #1	13	149	14	1 ± 1 ppb
Mars Center #1	40	113	12	1 ± 2 ppb
Mars Left	-42	155	15	0 ± 4 ppb
Mars Left	-8	123	13	0 ± 3 ppb
Mars Left	13	90	11	2 ± 4 ppb
Mars Right	0	192	18	0 ± 2 ppb
Mars Right	30	171	16	0 ± 2 ppb
Mars Right	56	126	13	0 ± 1 ppb
Mars Center #2	-17	172	16	1 ± 3 ppb
Mars Center #2	13	143	14	0 ± 1 ppb
Mars Center #2	40	107	12	1 ± 3 ppb

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