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Detection of hydrogen peroxide (H_2O_2) in the Martian atmosphere with MEX / PFS

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Abstract

We first derived the long-term averaged abundance of hydrogen peroxide (H_2O_2) in the Martian atmosphere with data sets of Planetary Fourier Spectroscopy (PFS) onboard Mars Express (MEX). The total averaged amounts of H_2O_2 at three Martian years were 45 ± 21 ppb and 25 ± 18 ppb in the forward/reverse pendulum direction, respectively. It could not explain the observed short lifetime of CH_4 in the Martian atmosphere.

1. Introduction

Recently, a non-negligible amount of CH_4 was detecteded in the Martian atmosphere [1]. This discovery is remarkable because possible sources include biological or geological activities. Recent observations show fast temporal and large spatial variation of CH_4 [2,3]. These results imply that the lifetimes of CH_4 is the order of weeks or months which, in turn, imply a strong sink, about 600 times faster than predicted by standard photochemistry processes [4]. It would suggest the existence of strong oxidants. Hydrogen peroxide (H_2O_2) is possibly one of the most important tracer elements for possible oxidants in the Martian atmosphere. However, only ground-based investigations [5] are currently available. The long term characteristics for the abundance, variability, and spatial distribution of H_2O_2 are uncertain.

2. Instrument and objective

The detection of H_2O_2 has not been reported yet by instruments onboard Martian orbiters. It requires higher spectral resolution in order to distinguish the weak absorption of H_2O_2 from the stronger absorptions by major constituents. At the moment, the Planetary Fourier Spectroscopy (PFS) aboard Mars Express (MEX) is the best instrument for this objective, which has the highest spectral resolution in the mid-IR range (~1.3 cm^{-1}) in previous orbiters. It has been operated for seven years on orbit. In this study, we derive the long-term averaged amount of H_2O_2 from this data set, and try to evaluate the possible loss scenario of CH_4 in the Martian atmosphere by oxidants in the atmosphere.

3. Data analysis and Results

We derived the long-term averaged abundance of H_2O_2 in the Martian atmosphere among three Martian years (from January 2004 to December 2009). By careful rejections of weak instrumental noises and averaging several thousands of measurements, we got the mixing ratio of Martian H_2O_2 with the accuracy of several tens ppb in the spectral range from 360 cm^{-1} to 385 cm^{-1}. The total averaged H_2O_2 mixing ratios were 45 ± 21 ppb in the forward pendulum direction, and 25 ± 18 ppb in the reverse pendulum direction, respectively. The annual averaged H_2O_2 mixing ratios were 50 ± 27 ppb and 43 ± 26 ppb at the MY 27, 0 ± 89 ppb and 0 ± 74 ppb at the MY 28, and 46 ± 21 ppb and 28 ± 20 ppb at the MY 29, respectively. The seasonal variation of H_2O_2 mixing ratio was 0 - 120 ppb during the observational period (see Fig. 1). We are now analyzing the origin of the discrepancy in forward/reverse data sets, but the amount of both is converged to similar values.

4. Discussions and conclusion

Our results are slightly larger than past ground-based and space-born observations and the photochemical models. This discrepancy can possibly be due to (1) artificial - the criteria used for our data selection, i.e., surface temperature between 250K and 270K and local time between 10 and 16; or (2) natural - unexpected transient enhancement might be included

(by electrostatic discharge appear during dust storms and dust devils). In both cases, this little discrepancy are not sufficient to explain the short lifetime of CH_4 recently observed [2,3]. By the assumption of photochemical steady state, we conclude that the atmospheric oxidation loss by OH cannot promote the observed fast variation of CH_4 (see Fig. 2 and Table. 1). We suggest that atmospheric oxidation loss by $O(^1D)$ and O may play an important role. On the other hand, no correlation between the variation of H_2O_2 and CH_4 has been found. This also suggests that the atmospheric electrochemical loss do not play major role in the fast variation for CH_4.

Table 1: The molecular number density assumed in photochemical steady state for H_2O_2 and OH.

Mol.	Number density (cm^{-3})	Ref.
H_2O_2	1×10^{9} - 1×10^{10}	this study
H_2O	1×10^{13}	this study
CO	1×10^{14}	[6]
O	5×10^{7}	[7]
$O(^1D)$	0.9	[7]
O_3	5×10^{9}	[7]
H	5×10^{4}	[7]
H_2	5×10^{8}	[7]

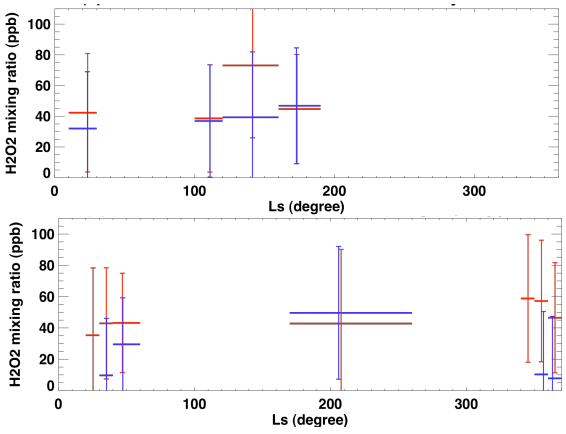

Figure 1: The seasonal variation of the mixing ratio of H_2O_2 derived by the PFS/LW in the MY 27 (top), and in the MY 29 (bottom). The vertical bars of each data point are the standard deviation and the horizontal bars are the averaged duration. The red lines are the FWD data sets and blue lines are REV data sets.

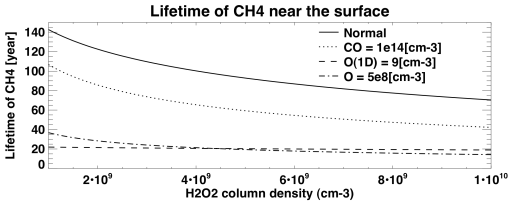

Figure 2: The expected calculated photochemical lifetime of CH_4 affected by the abundance of H_2O_2 near the surface. Solid line shows the lifetime with the input normal parameters listed in Table 1. The dotted line shows the lifetime with the 5×10^{8} cm^{-3} of CO. The dashed lines show the values with the 10 times larger abundance of $O(^1D)$ and O than the lifetime predicted by [7].

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References

[1] Formisano, V., Atreya, S.K., Encrenaz, T., Ignative. N., and Giuranna, M.: Detection of methane in the atmosphere of Mars, Science, 306, 5702, 1758-1761, 2004.

[2] Mumma, M., Villanueva, G., Novak, R., Hewagama T., Bonev, B., Disanti, M., Mandell, A., and Smith, M.: Strong release of methane on Mars in northern summer 2003, Science, 323, 5917, 041-1045, 2009.

[3] Geminale, A., Formisano, V., Sindoni, G., and Atreya, S.: Mapping methane in Martian atmosphere with PFS-MEX data, Planet. Space Sci., 59, 137 -148, 2011.

[4] Lefèvre, F., and Forget, F.: Observed variations of methane on Mars unexplained by known atmospheric chemistry and physics, Nature, 460, 7256, 720-723, 2009.

[5] Encrenaz T., Greathouse, T.K., Lefèvre, F., and Atreya, S.K.: Hydrogen peroxide on Mars: Observations, interpretation and future plans, Planet. Space Sci., in press.

[6] Sindoni, G., Formisano, V., and Geminale, A.: Observations of water vapour and carbon monoxide in the Martian atmosphere with the SWC of PFS/MEX, Planet. Space Sci., 59, 149-162, 2011

[7] Krasnopolsky , V.A, Photochemistry of the martian atmosphere: Seasonal, latitudinal, and diurnal variations, Icarus, 185, 153–170, 2006