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Occultation results by ACS TIRVIM at ExoMars TGO: aerosols and gases

Alexey Grigoriev (1), **Alexey Shakun** (1), Nikolay Ignatiev (1), Boris Moshkin (1), Dmitry Patsaev (1), Alexander Zharkov (1), Igor Maslov (1), Dmitry Gorinov (1), Andrey Kungurov (1), Aleksandr Santos-Skripko (1), Viktor Shashkin (1), Fedor Martynovich (1), Oleg Sazonov (1), Igor Stupin (1), Dmitry Merzlyakov (1), Yury Nikolskiy (1), Mikhail Luginin (1), Alexander Trokhimovskiy (1), Franck Montmessin (2), and Oleg Korablev (1)
(1) Space Research Institute (IKI), Moscow, Russia, (2) LATMOS-CNRS, Guyancourt, France (avshakun@iki.rssi.ru)

Abstract

ACS is a set of three spectrometers (NIR, MIR, and TIRVIM observing the Mars atmosphere in solar occultations, nadir and limb geometry. It was built by Space Research Institute (IKI) in Moscow (Russia) [1]. ACS TIRVIM is a Fourier-spectrometer built around a 2-inch double-pendulum interferometer with cryogenically-cooled HgCdTe detector, allowing operation in nadir and in solar occultation. The primary goal of TIRVIM is the long-term monitoring of atmospheric temperature profiles and aerosol state in nadir (see Ignatiev et al. EPSC 2018).

TIRVIM is the first Fourier-spectrometer able to observe Sun occultations at Mars giving an access to a broad spectral range from near-IR through thermal IR: 1.7-17 µm. A dedicated solar port with limited aperture, or the full 2” nadir aperture could be used to observe occultations. In either case the FOV diameter is 2.5°, while the spectral resolution changes from 0.8 cm^{-1} when observing through the solar port (the “climatology” observation mode) to 0.13 cm^{-1} when observing with full nadir aperture. This latter “sensitive” mode requires dedicated spacecraft pointing, but allows for sensitive measurements of trace atmospheric gases.

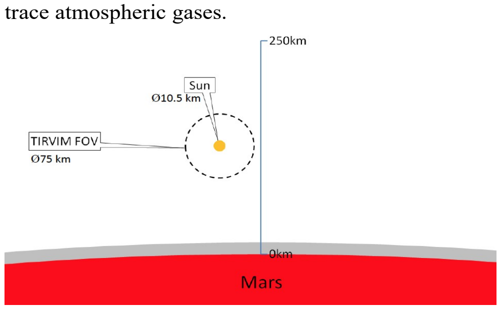

Figure 1: A sketch of TIRVIM observation geometry in occultation.

At the limb the FOV encompasses a circle of 75 km while the Sun disk diameter is 10.5 km. In the short-wavelength (SW) part of the spectrum the Sun radiation dominates and the Sun diameter mostly determines the effective FOV. In the long-wavelength (LW) part the infrared emission from Mars and the atmosphere is significant or dominates and the full FOV works. The vertical sampling in the “climatology” mode is as low as 0.4 km.

The first Sun occultations showed that the following gaseous bands are well visible in the TIRVIM spectra: multiple CO_2 bands, CO at 4.7 µm, H_2O at 6.3 µm. All these gases are routinely observed in “climatology” mode allowing for vertical profiling. The CO_2 in the 15-µm band is detectable up to the altitude of ~200 km, with a signature of non-LTE effects.

The “climatology” spectra reveal vertical structure of aerosols, sometimes layered. The spectra show H_2O ice features at around 3 µm and 12 µm. An interesting optical phenomenon is observed around the 12-µm ice and 9-µm silicate dust bands. When the Sun approaches the horizon, a sort of emission with a particularly strong and sharp peak around 9-10 µm appears. The intensity increases by an order of magnitude in 10 s and remains at this level even when the Sun falls ~16 km below the horizon. Our preliminary interpretation is that the large TIRVIM FOV acquires the Sun IR light forward-scattered by the silicate dust particles. Just the same but time-reversed picture is visible at the sunrise. We call this effect "Silicate Dawn-Dusk" (SDD). SDD is observed in both hemispheres, at different places. A detailed interpretation of SDD effect would involve comprehensive modeling (Luginin et al., EPSC 2018) but should deliver a lot of information about aerosols.

TIRVIM occultations observed with the “sensitive” pointing allow to profile trace components. So far

CO_2 isotopic bands including 628 were observed. Less pronounced but detectable is O_3 at 9.6 µm; for NH_3 an existing upper limit of 8 ppb [2] could be improved.

The TIRVIM occultation results available will be reviewed, and the progress of their interpretation summarized.

Acknowledgements

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