First observation of the magnetic dipole CO2 main isotopologue absorption band at 3.3 μm in the atmosphere of Mars by ACS ExoMars

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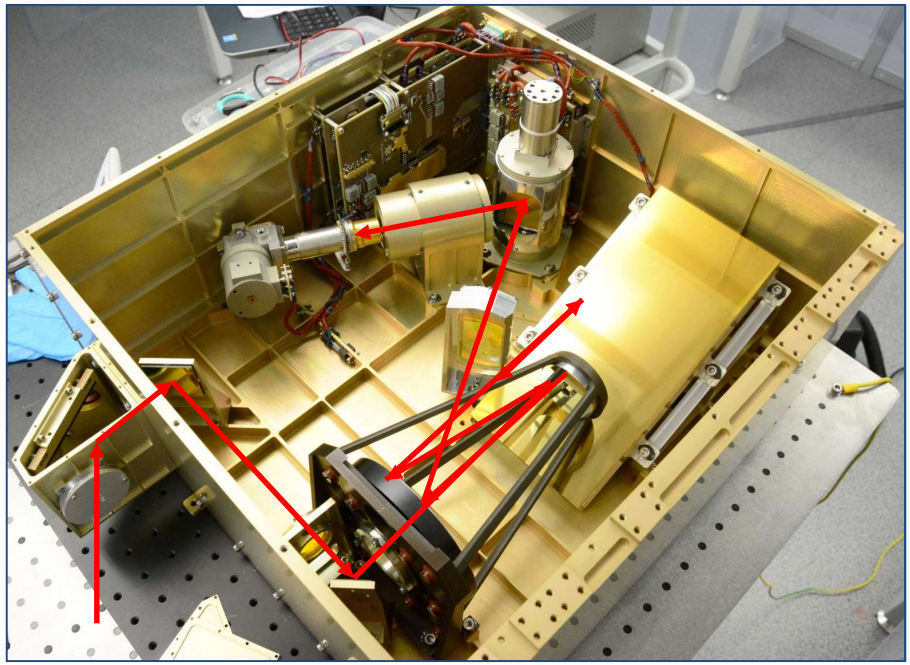
ACS MIR: Mid-IR Echelle/cross-dispersion

• **Spectral range:**	**2.3 – 4.2 µm**
• **Instantaneous coverage:**	**90-270 nm ranges per measurement**
• **Spectral resolving power:**	**~ 30 000**
• **Instantaneous FOV:**	**0,23×0,02° (14'x 1') full slit**
	<1' for a single pix
• **Aperture ratio**	**1:3**
• **Operation modes:**	**Solar Occultation**
• **Operation rate in Sensitive mode**	**~1 accumulated images per 2.1 s**
• **SNR**	**>5000 for a single pixel**

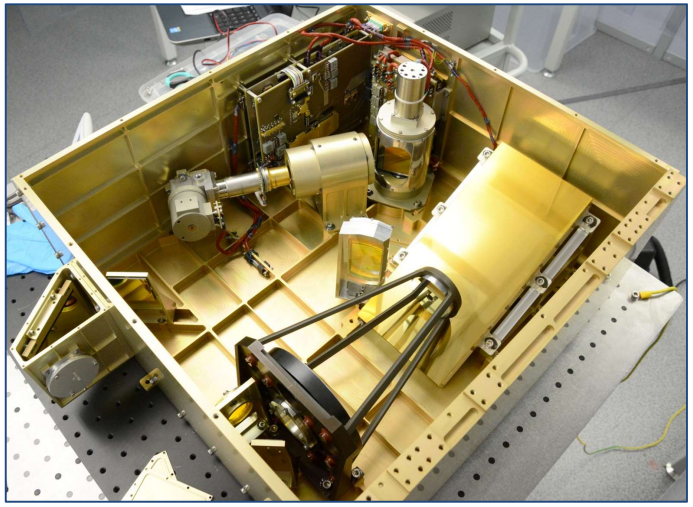
- Breakthrough and Novel TGO science
- 7 lenses, 3 aspherical mirrors, echelle grating, two diffraction gratings, precise rotational unit, 3 flat mirrors, cryocooler and MCD detector, two sets of electronics
- ACS MIR is generating data by recording frames from a 640×512 pixels detector. Each frame contains a 90 to 270 nm spectral range, depending on a secondary grating orientation. Orientation is controlled by a rotational unit

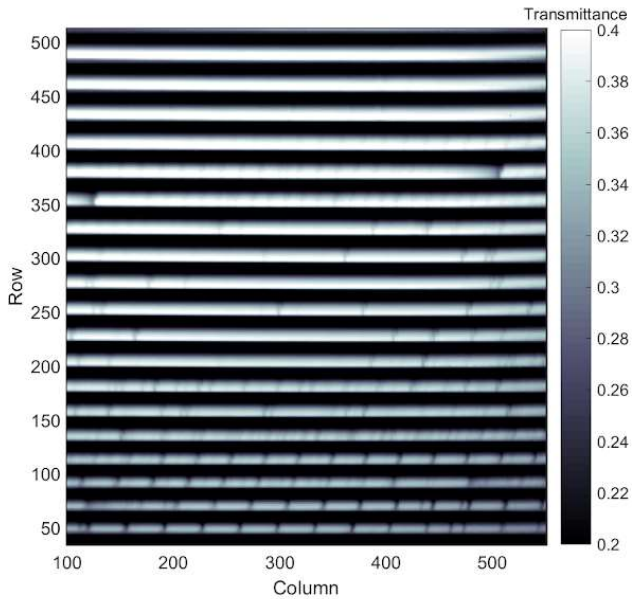


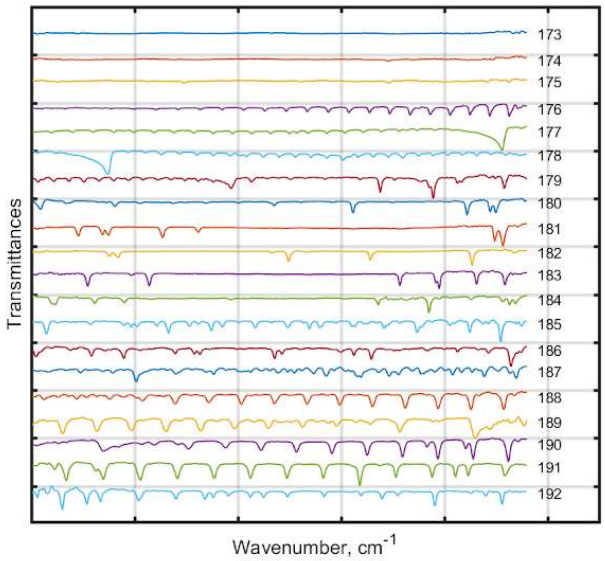
ACS MIR Echelle/cross-dispersion for trace species detection

Why ACS MIR?

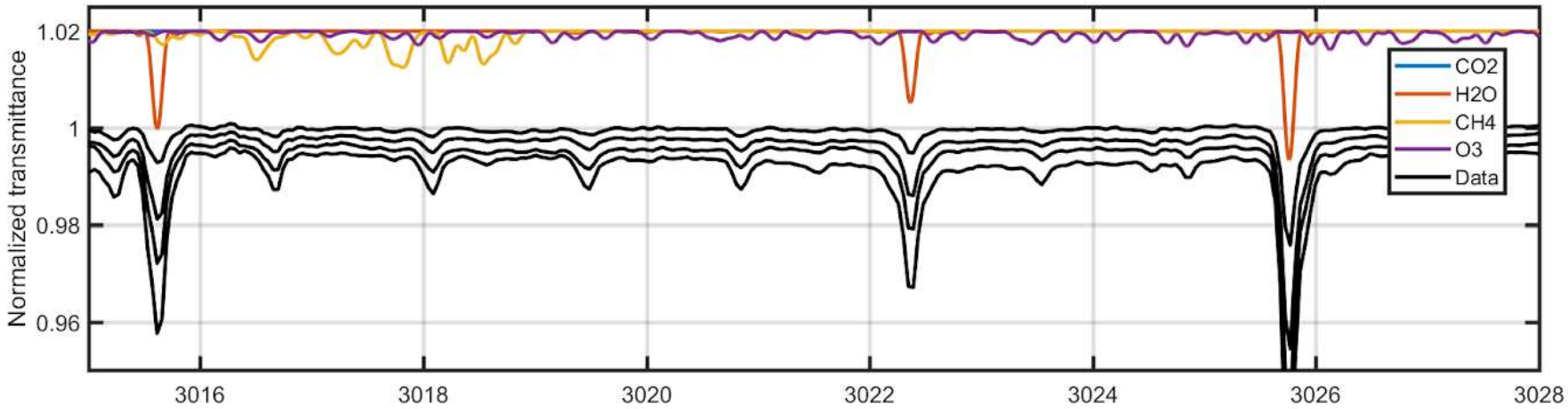
- Spectral range
- No orders overlapping
- Aperture ratio F:3, both polarization registered, fast onboard accumulation, thermal background shielded => amazing SNR
- High spectral resolution
- Wide instantaneous coverage







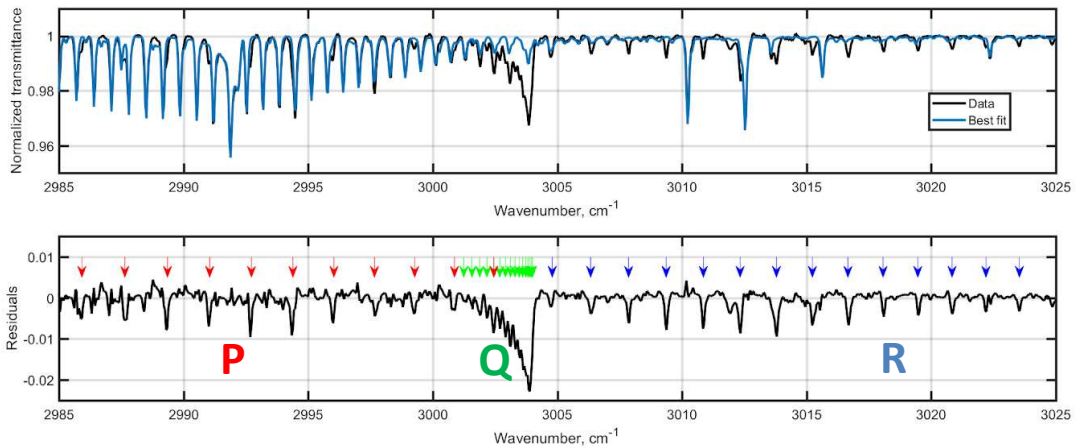
Unknown periodic spectra in the spectra

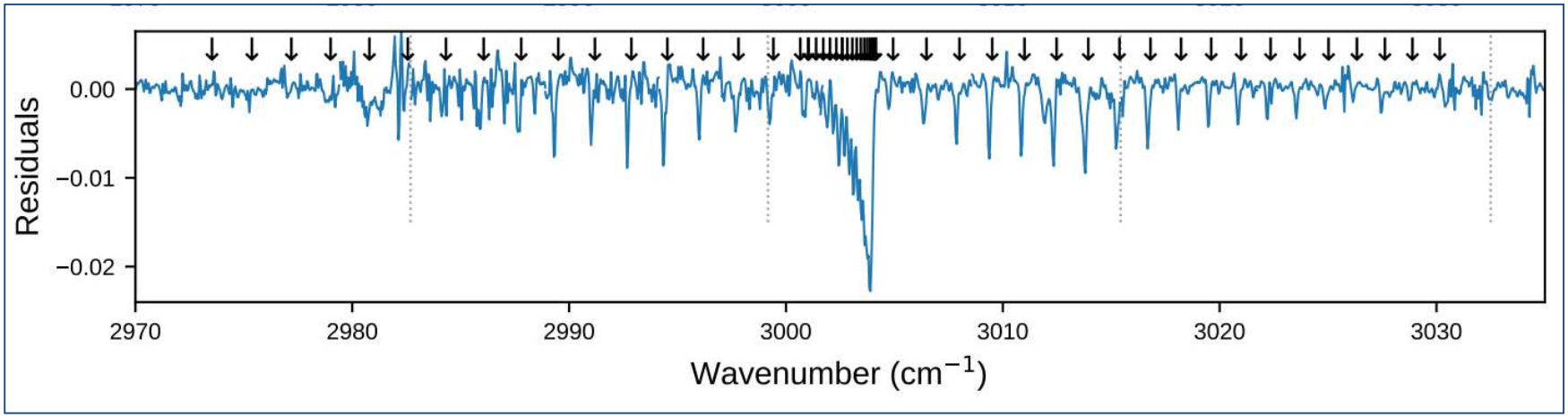


A number of consecutive ACS MIR transmission spectra measured in diffraction order 180 at tangent altitudes 8–18 km (Orbit 7067 black curves), against synthetic models indicating potential contributions of different atmospheric components at MIR resolution (coloured curves): 15 ppm of water vapour, 1 ppb of methane and 200 ppb of ozone . Three H_2O lines and a series of periodic unidentified features are apparent.

Identifying new lines

- Periodic spectra suggests a linear or diatomic molecule in the Martian atmosphere
- Main focus of the search to unknown CO and CO2 lines
- Lines observed by ACS MIR regularly on clean orbits
- Perfect match for 01111-00001 band of 12C16O2. This band is forbidden in the electric dipole absorption but it is allowed in the electric quadrupole and the magnetic dipole absorption, both never been observed
- Hönle-London factors for the $\Delta\ell_2=1$ magnetic dipole and electric quadrupole absorption bands show that electric quadrupole should have O- and S- branches, and weak Q- branch, while in the data we observe strong Q- and no S-,O-.
- New lines are eventually assigned to the magnetic dipole CO2 main isotopologue band



Summary

- Weak lines in the methane range around 3018 cm^{-1} are the first observation of the magnetic dipole 12C16O2 absorption. The electric quadrupole input is at least several times smaller.
- Calculated lines positions perfectly match the data.
- Lines strengths and their temperature dependency measured by comparing equivalent widths with known CO2 lines. Temperatures from simultaneous ACS NIR observation.
- Paper submitted to the A&A.