Sensitive Probing of Exoplanetary Oxygen in the Mid-Infrared

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Oxygen absorptions within JWST spectral range

Before this work:

- The O_2 A-band at 0.76 μm in the visible
- The O_2-O_2 *Collision-Induced Absorptions* (CIAs) at 1.06 and 1.27 μm in the Near Infrared

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Inelastic collision in a gas producing distinct spectral features

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After this work:

- The O_2-X CIA at 6.4 μm in the Mid-Infrared (JWST MIRI range)

Why was it previously missing?

- No CIA included in some RT models
- Incomplete / obsolete spectral databases
- Only O_2–O_2 feature at 6.4 μm is included in HITRAN, not O_2-X features
- Overlapping with H_2O absorption band

The Mid-Infrared O_2-X CIA in the Earth Science literature..

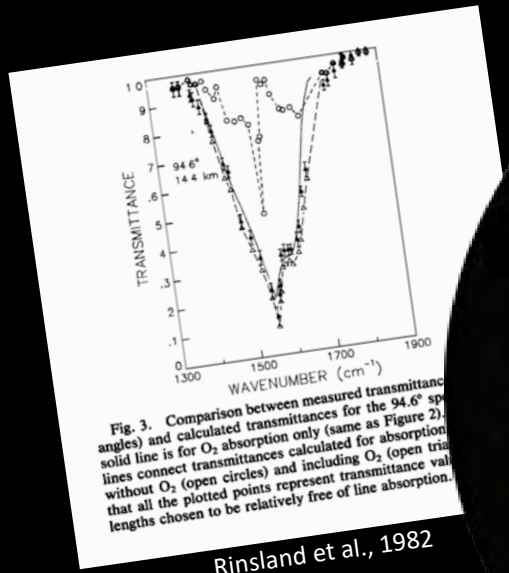
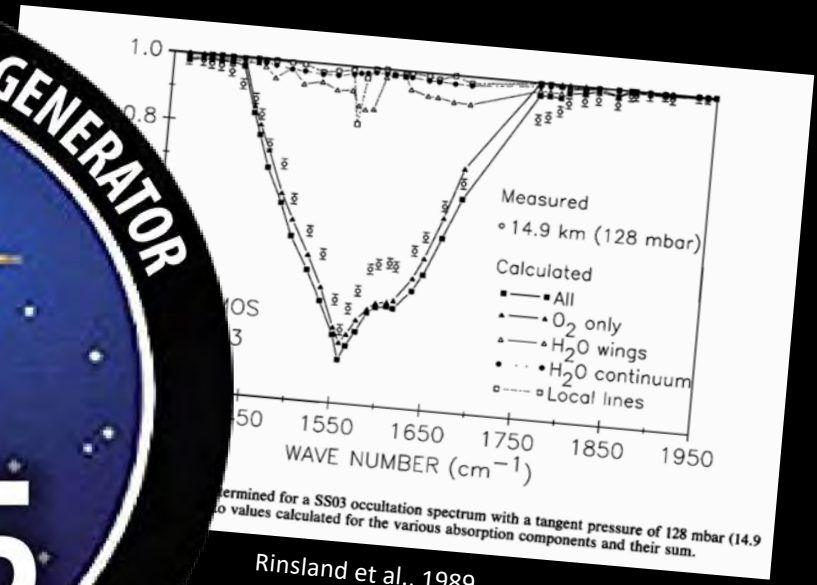


Fig. 3. Comparison between measured transmittanc
angles) and calculated transmittances for the 94.6° sp
solid line is for O_2 absorption only (same as Figure 2).
lines connect transmittances calculated for absorption
without O_2 (open circles) and including O_2 (open tria
that all the plotted points represent transmittance val
lengths chosen to be relatively free of line absorption.

Rinsland et al., 1982



ermined for a SS03 occultation spectrum with a tangent pressure of 128 mbar (14.9
o values calculated for the various absorption components and their sum.

Rinsland et al., 1989

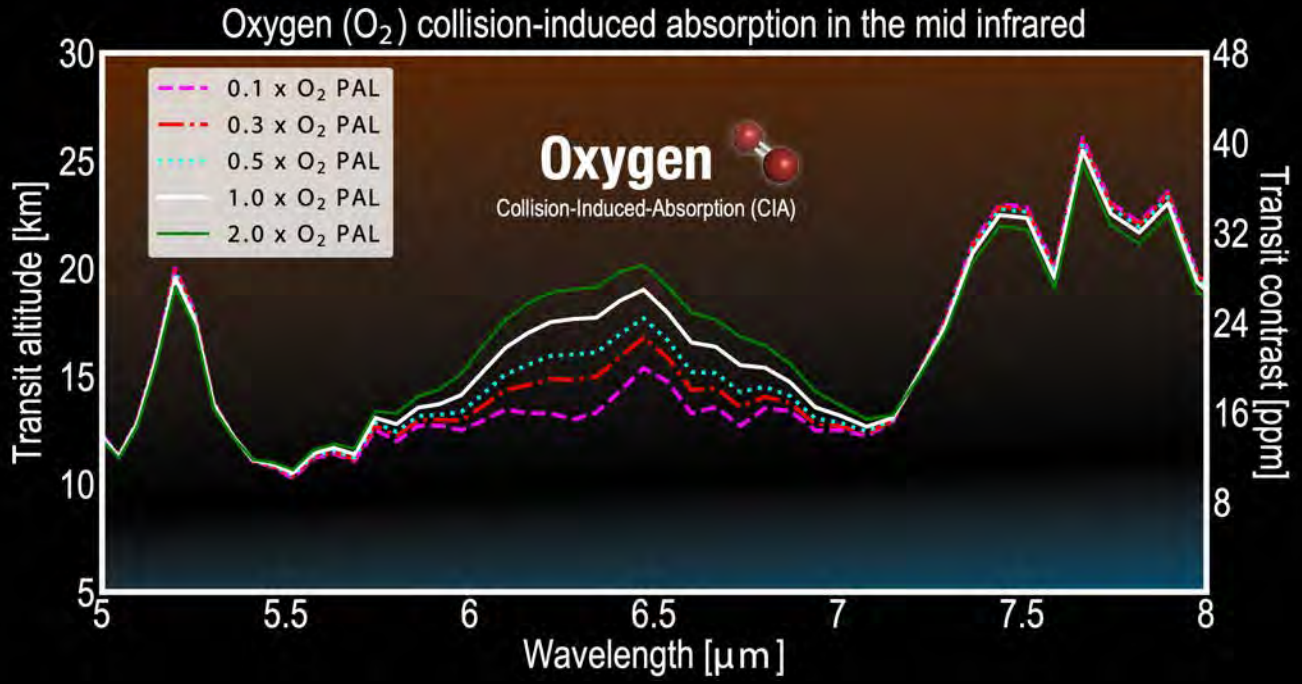
Fig. 7. Abso of temperature.

PLANETARY SPECTRUM GENERATOR

PSG

NASA

Simulated transmission spectra of TRAPPIST-1e with JWST MIRI



O_2-X CIA is very sensitive to the oxygen pressure and dominates the 6 to 7 μm region

Modern Earth-like atmosphere

Artist illustration of TRAPPIST-1e with a modern Earth -like atmosphere

TRAPPIST-1e as a benchmark..

Within 5 pc from the Sun:

O_2-X CIA at 6.4 μm is the *only* O_2 feature potentially detectable with JWST

Beyond 5 pc:

Not detectable with JWST

Desiccated O_2-dominated atmosphere

Artist illustration of TRAPPIST-1e with a desiccated O_2-dominated atmosphere

TRAPPIST-1e as a benchmark..

<u>Up to 25 pc from the Sun:</u>

- Both the 1.27μm O_2-O_2 and 6.4 μm O_2-X CIAs could detect dense O_2 desiccated atmospheres.

- The 6.4 μm O_2-X CIA requires less transits than the other O_2 features

Conclusions

The 6.4 μm O_2–X CIA may be the most detectable O_2 feature for transit observations.

✓ **Within 5 pc:**

- The only O_2 feature to detect modern Earth levels of oxygen detectable at 5 sigma.

✓ **Beyond 5 pc (up to ~ 25 pc):**

- Desiccated dense O_2 atmospheres in less transits than the other O_2 features