

## Combined spectra of Titan with EXES/SOFIA.

EXES observed high-resolution spectra of Titan on several occasions to search for new molecules. There were four successful observations.

PLANID	Wavenumbers	Flights Observed	filename
08_0203	400.4-404.2 $\text{cm}^{-1}$	Flight 747, 749	titan_403cm-1_combined.dat
08_0203	469.3-475.8 $\text{cm}^{-1}$	Flight 747, 749, 799	titan_472cm-1_combined.dat
08_0203	617.5-624.2 $\text{cm}^{-1}$	Flight 744	titan_621cm-1_corrected.dat
86_0006	743.5-750.3 $\text{cm}^{-1}$	Flight 198	titan_746cm-1.dat

Standard conventions:

The wavenumber scale has been shifted to Titan's rest velocity at the time of observation, using the ephemeris on JPL Horizons.

The fluxes are given in Janskys and have been corrected for slit throughput losses, using the procedure described in the EXES Handbook for Archive Users.

Notes on specific observations:

### **titan\_403cm-1\_combined.dat**

Observations taken on 2 nights, which were Doppler shifted to Titan's rest velocity, and then combined by weighting each observation to the inverse square of its RMS noise.

There was nearly zero interference from the atmosphere at these wavelengths and consequently the calibrator asteroid Vesta was not used.

We are unaware of any line detections, but the line lists for complex hydrocarbons targeted (Pyridine, others) were not unavailable to us.

### **titan\_472cm-1\_combined.dat**

Observations taken on 3 nights, which were Doppler shifted to Titan's rest velocity, and then combined by weighting each observation to the inverse square of its RMS noise.

Atmospheric water and nitric acid were removed by using the dedicated telluric calibrator observation Vesta. Regions with < 50% transmission were masked before combining the 3 epochs.

We are unaware of any line detections, but the line lists for complex hydrocarbons targeted (Pyridine, others) were not unavailable to us.

### **titan\_621cm-1\_corrected.dat**

Observations taken on only 1 night, with the adjacent calibrator Callisto. We shifted the wavenumber scale to Titan's rest velocity. The Callisto spectrum was normalized to 1, and divided from Titan.

Then the flux was divided by the approximate slit throughput, 0.66 to obtain the true flux of Titan.

The spectrum has detections of  $C_4H_2$  (diacetylene) and  $C_3H_4$  (methylacetylene).

### **titan\_746cm-1.dat**

Observations taken on only 1 night. The telluric calibrator Pallas was found to be too poor quality to use, and thus this observation must be divided by a telluric model, which is provided in the file. The observation was interrupted by telescope tracking errors, and data was taken in 3 blocks where the Titan position on the slit changed and the nod throw was adjusted.

A custom extraction procedure was written to handle the changing source position and also to extraction partial order coverage that was rejected by the pipeline.

The wavenumber scale is shifted to Titan's rest velocity at the time of the observation.

Because of changing flux calibration procedures, the accuracy of the absolute flux is questionable.

See Roe et al. 2003 for Titan spectrum with partial coverage of this region, observed with TEXES on IRTF.

The spectrum has detections of  $C_2H_2$  (and isotopes), HCN (and isotopes) and  $C_3H_8$  (propane).

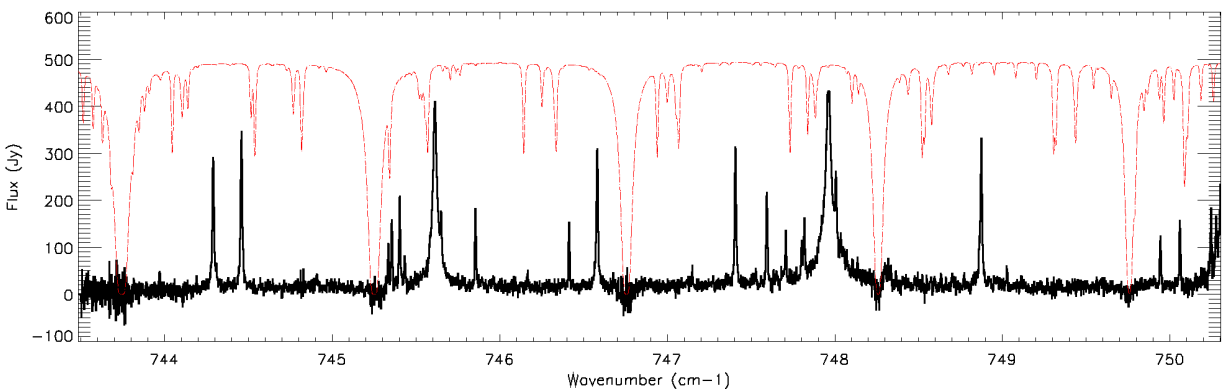


Figure 1 Titan at 746cm-1, with telluric transmission in red.

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# Titan in its rest frame, derived from
# F0198_EX_SPE_86000611_EXEELONEXEECHL_COA_95150-95152.fits,
# F0198_EX_SPE_86000611_EXEELONEXEECHL_COA_95160-95161.fits,
# & F0198_EX_SPE_86000611_EXEELONEXEECHL_COA_95162.fits.
#####
# Wavenumber (cm-1)    Flux (Jy)          Flux Variance      Transmission
743.486846            -NaN              Infinity           0.947
743.487846            0.0000           1.4042            0.947
743.488845            0.0000           1.1724            0.946
743.489845            0.0000           0.9601            0.945
743.490845            0.0000           0.7672            0.945
743.491845            0.0000           0.5937            0.944
743.492845            0.0000           0.4397            0.943
743.493845            0.0000           0.3051            0.942
743.494845            0.0000           0.1900            0.940
743.495845            0.0000           0.0943            0.939
743.496845            0.0000           0.0181            0.937
743.497844            0.0000           0.0386            0.935
743.498844            -0.4126          0.0759            0.932
743.499844            -16.7481         0.0938            0.928
743.500844            -8.5011          0.0922            0.924
743.501844            -11.2918         0.0903            0.918
743.502844            -51.3897         0.0994            0.911
743.503844            -19.8675         0.1017            0.902
743.504844            1.6349           0.1024            0.890
743.505844            -5.1933          0.1053            0.876
743.506843            53.2441         0.1085            0.859
743.507843            52.8546         0.1105            0.839
743.508843            22.4668         0.1133            0.818
743.509843            -9.6695          0.1136            0.795
743.510843            -5.2111          0.1129            0.772
743.511843            16.8379         0.1135            0.753
743.512843            -3.0465          0.1133            0.738
743.513843            -19.2432         0.1093            0.730

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Figure 2: Part of file *titan\_746cm-1.dat*