Following the Carbon: Structure, Chemistry, and Spectroscopy of Frozen Ethane

Lily Raines (Eckerd College)
Dr. Marla Moore (GSFC)
Dr. Reggie Hudson (Eckerd College)

Why Ethane?

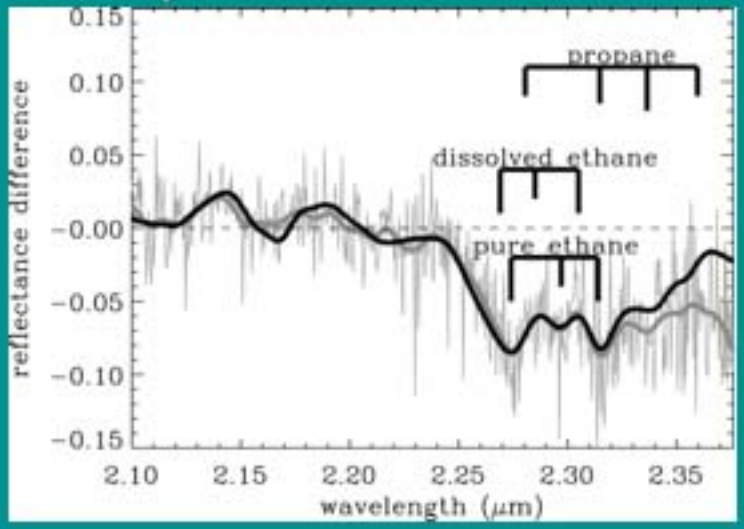
- Found in many TNO's

  ex: Oort Cloud comets, Pluto, Quaoar, 2005 FY9.

- Forms from the irradiation of methane, which is abundant throughout the solar system

- Current data not thorough

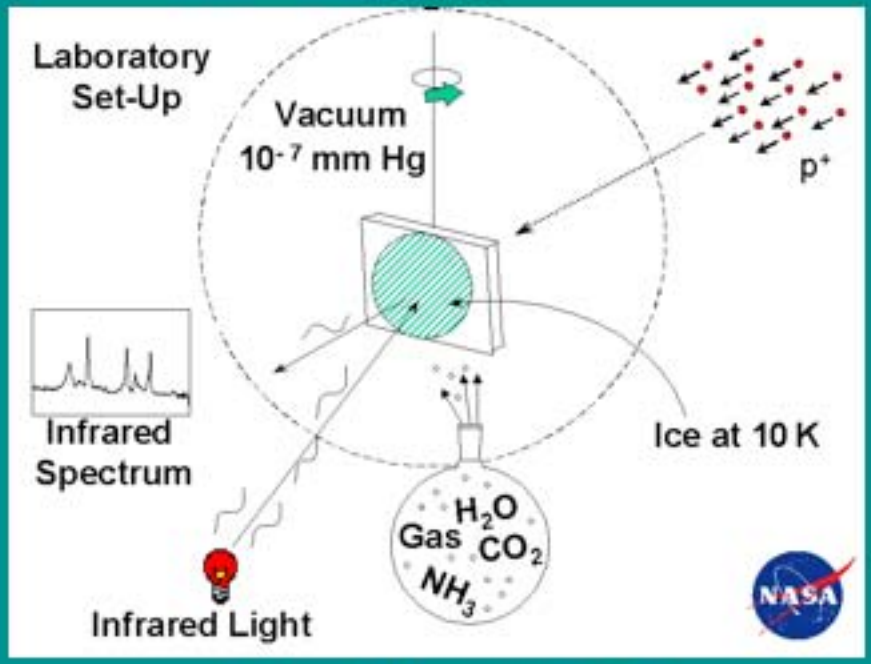
Comet Hyakutake. © R.Scott and J. Orman



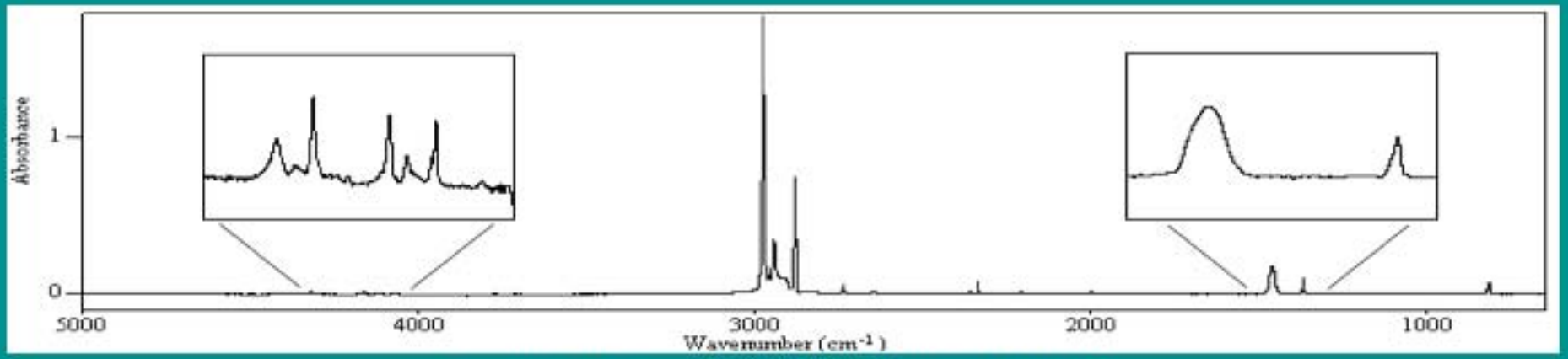
Spectrum of 2005 FY9 shows ethane. (Brown et al)

Experimental Methods

- Formed ice samples by condensing gases onto a small substrate at the desired temperature.
- Used IR spectrometry to observe changes in composition with changing temperature and ion-irradiation.



General Laboratory Set-Up



Spectrum of amorphous ethane deposited at 13 K

A-Value Determinations

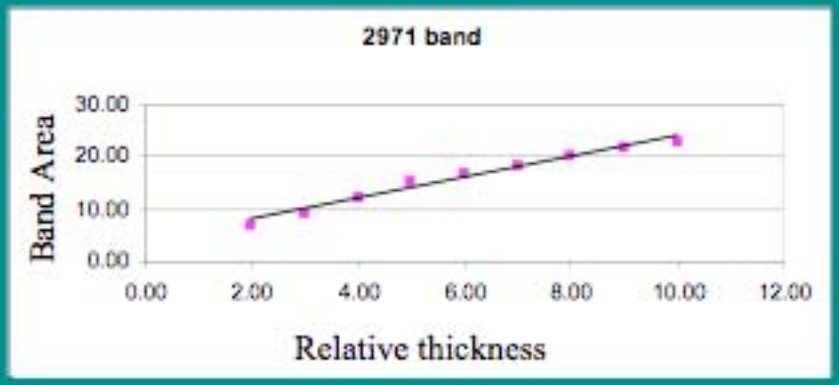
$$A=\left[\frac{(2n)(mw)(2.303)}{(\lambda)(\rho)(N_A)}\right]\left[\frac{\int(Abs)dv}{(N_f)}\right]$$

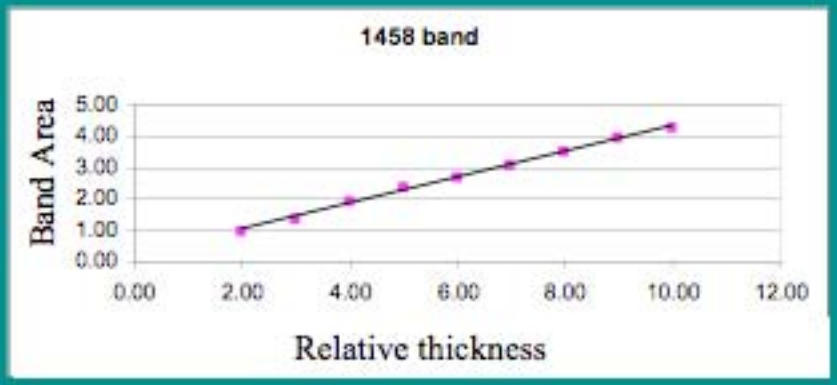
A-Values Metastable C_2H_6

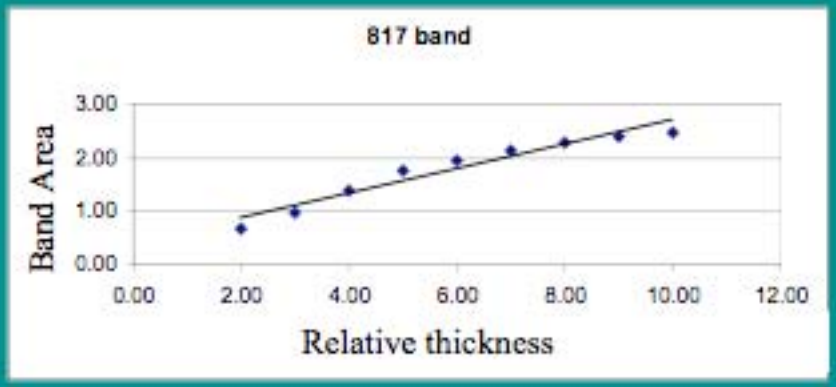
(in cm/molecule):

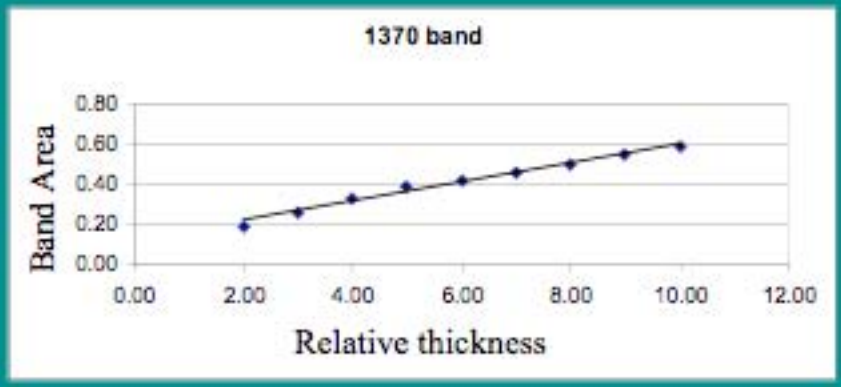
2971 cm^{-1}:7.38 x10^{-18} 1370 cm^{-1}: 1.51x10^{-19}

1458 cm^{-1}: 1.68x10^{-18} 817 cm^{-1}: 9.24x10^{-19}

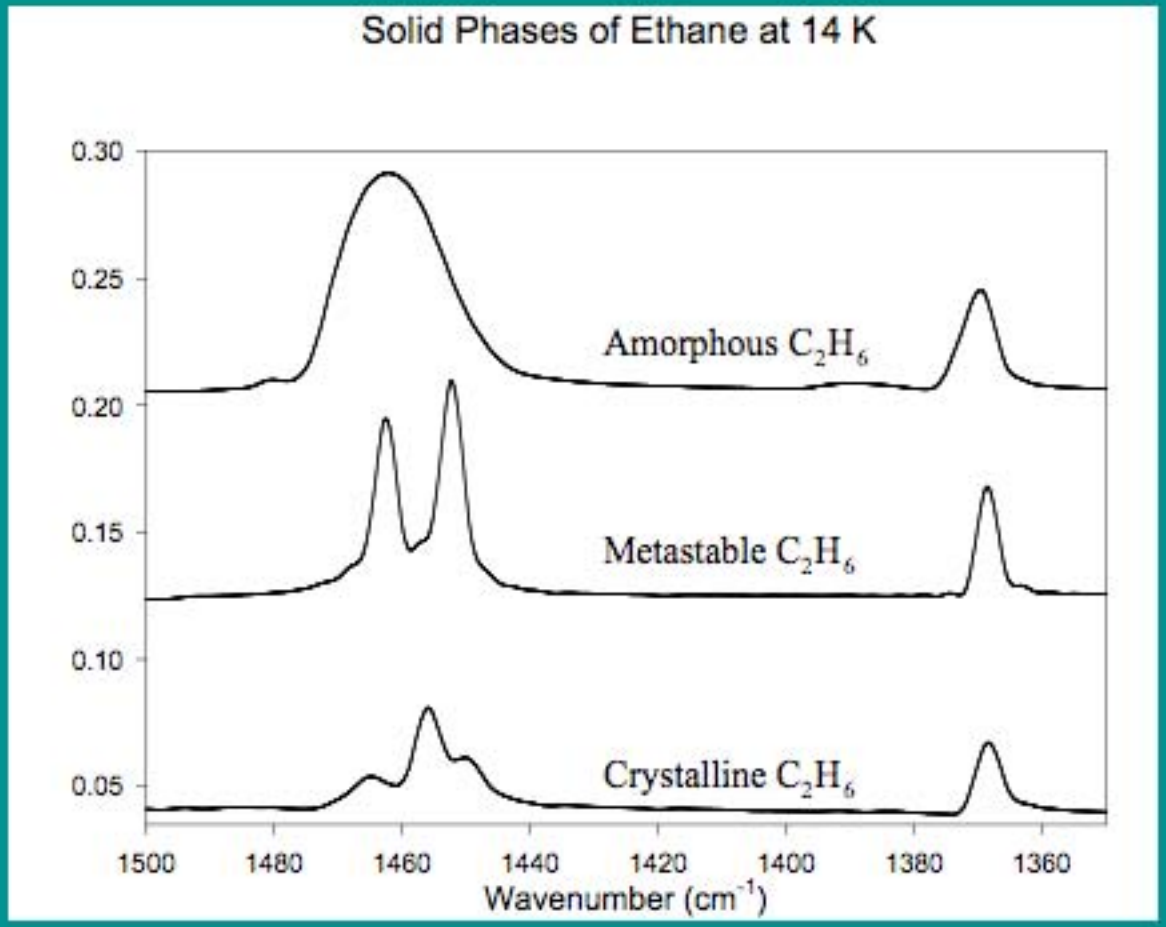








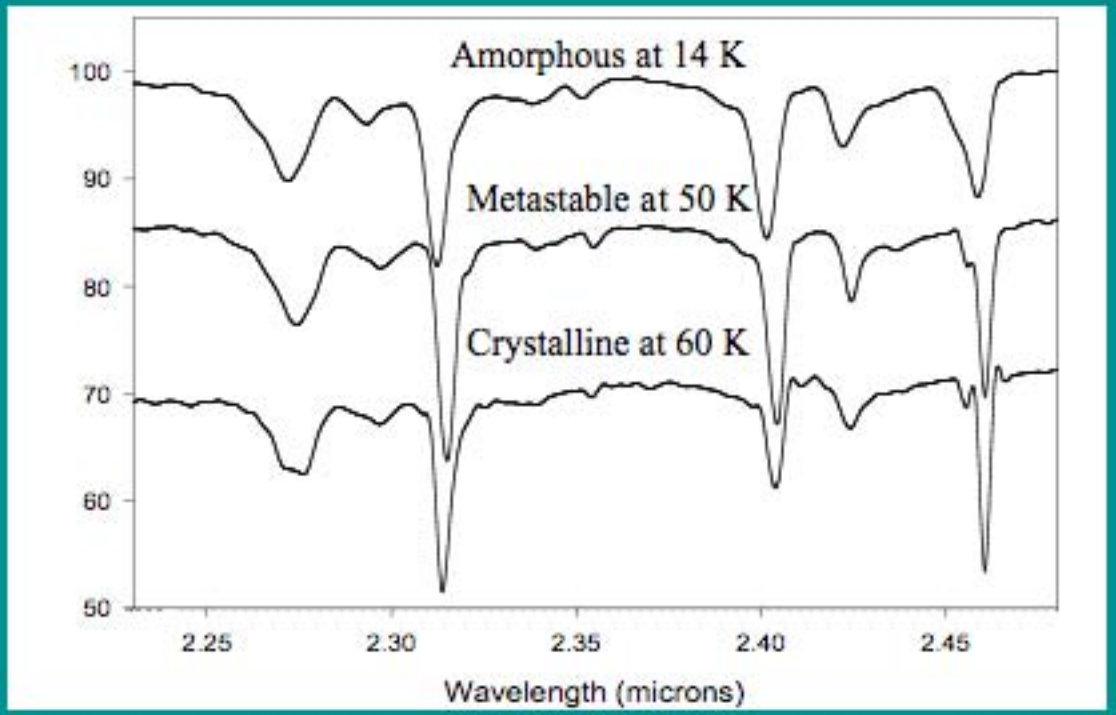
Different Phases of Ethane



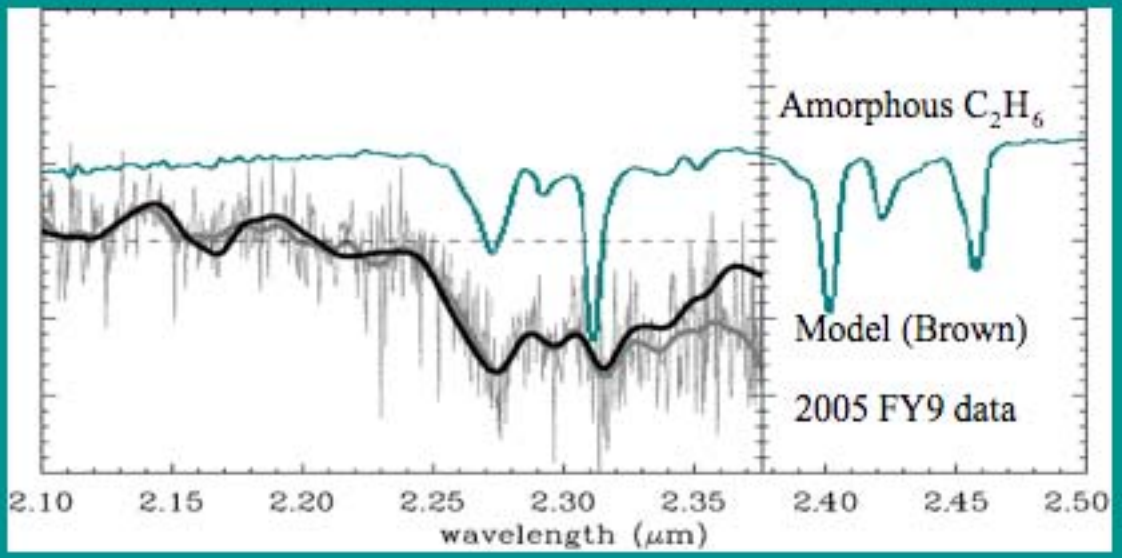
Spectra showing the peaks at 1460 cm^{-1} for amorphous, metastable, and crystalline ethane at 14 K.

Ethane in the Near-IR

Spectra of amorphous, metastable, and crystalline ethane in the near-IR.

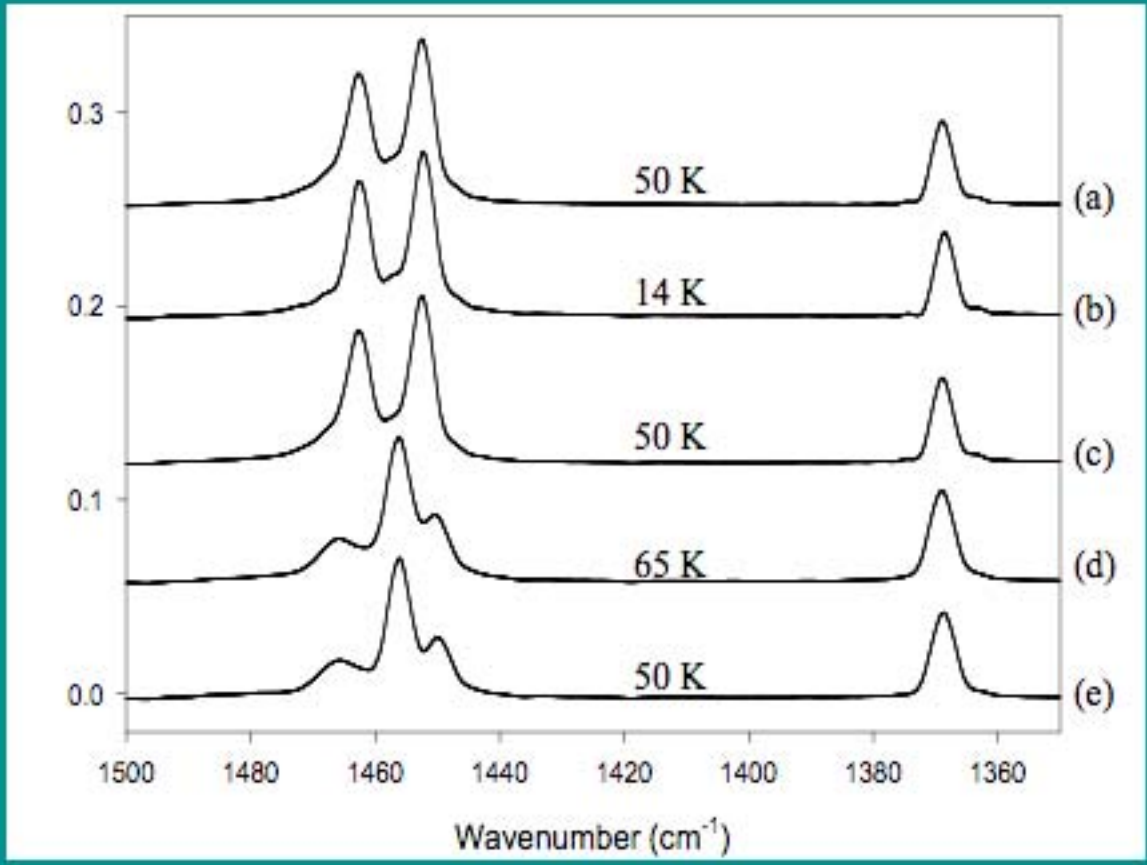


Spectrum from 2005 FY9 overlaid with a near-IR ethane spectrum.



Effects of Temperature

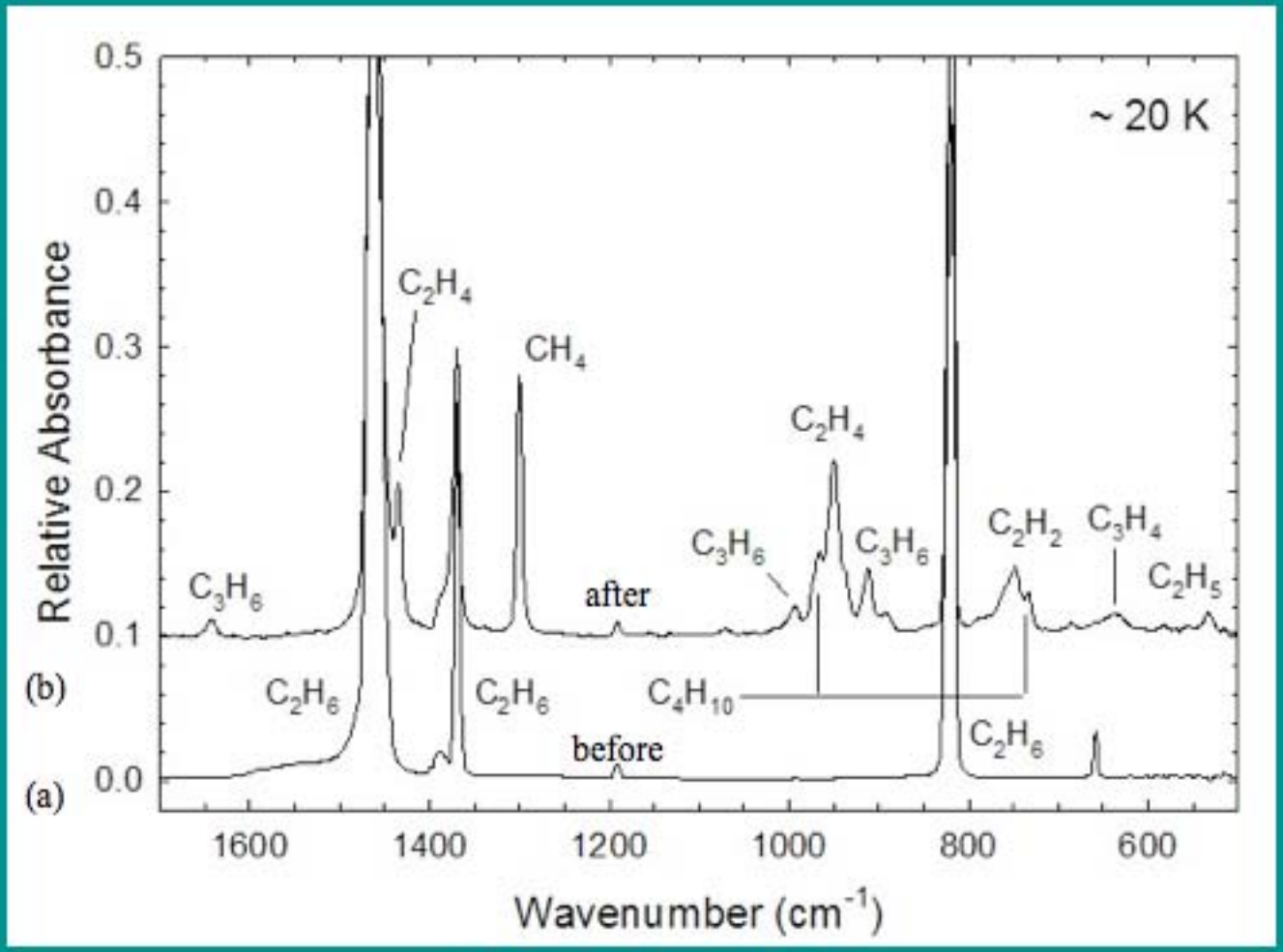
- Deposition Temperatures
  - Amorphous: 10 - 25 K
  - Metastable: 25-50 K
  - Crystalline: 50 - 60 K



Temperature cycling of metastable ethane deposited at 50 K.

- C_2H_6 ices will retain their structure when cooled
- C_2H_6 irreversibly converts to the crystalline state when heated to 65 K.

Radiation Products and Decay



(a) Non-irradiated Ethane
(b) Ethane exposed to 0.8 MeV at 20 K. Total dose=10 eV/molecule

- Many different hydrocarbons are produced when C_2H_6 is ion-irradiated. The remaining C_2H_6 becomes amorphous.

Conclusions

- The differences between amorphous, metastable, and crystalline ethane in IR spectra are significant.
- Ethane ices will preferentially form crystalline structures unless they remain at temperatures below 60 K.
- Ethane ices will become amorphous and will produce other hydrocarbons when exposed to radiation in the form of accelerated protons.
- Improved understanding of ethane may contribute to future searches for hydrocarbons in the outer solar system.

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