Vacuum-UV spectroscopy of interstellar ice analogs.

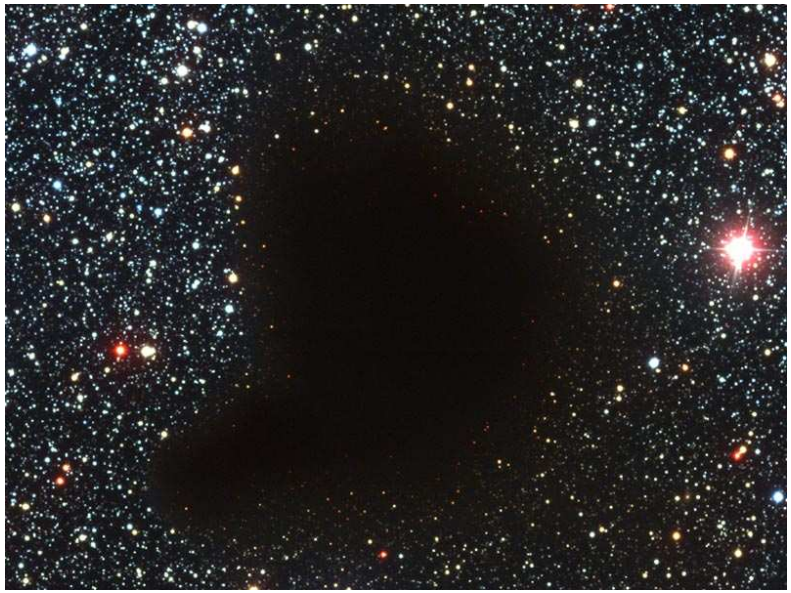
G. A. Cruz-Diaz, G. M. Muñoz Caro, and Y.-J. Chen

January 21st, 2013

Interstellar medium

- **Dense interstellar clouds**: T $\sim$ 10 K, density $\tilde{1}0^5$ particles cm^{-3} mainly H_2.
- **Dust particles**: composed of refractory materials such as silicate and amorphous carbon. Icy mantles represent the transient interface between gaseous and solid phases.
- **UV-photons**: are either produced in the vicinity of a young star, or induced by cosmic ray excitation of H_2, 10^8 photons cm^{-2} s^{-1}, 10^3-10^4 photons cm^{-2} s^{-1} respectively.

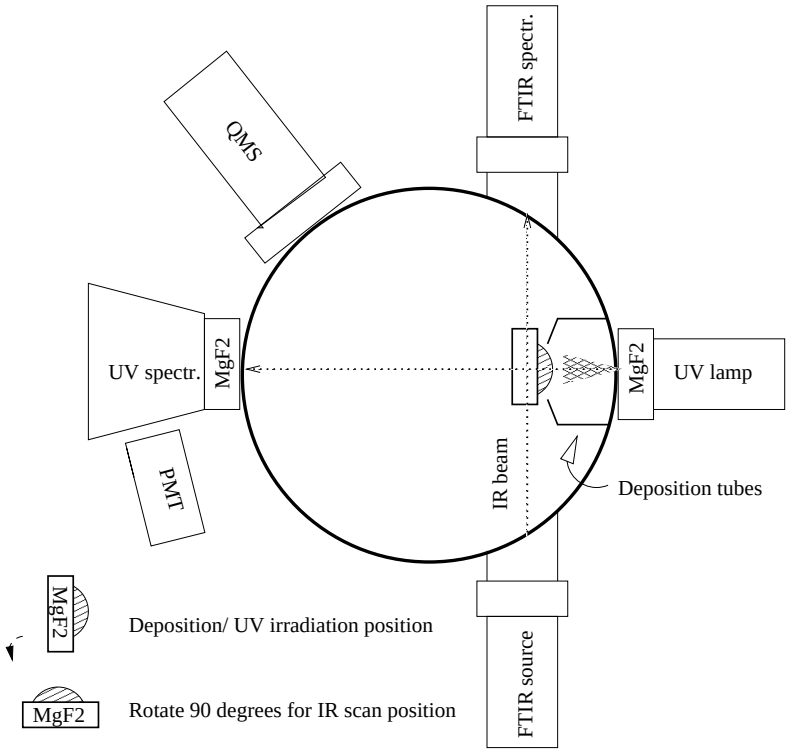
The Loschmidt's number (2.7×10^{19} particles cm^{-3}) enables a rough estimate of the pressure in the dense interstellar medium, 10^{-11} mbar.



Molecular cloud Barnard 68.

ISAC

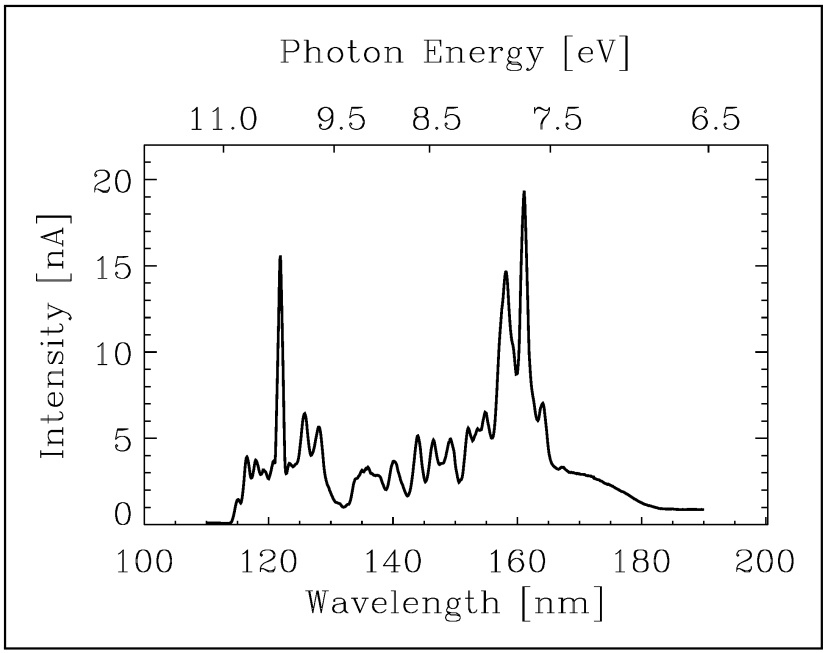
- **The InterStellar Astrochemitry Chamber** is an UHV set-up, with base pressure around **P = 4**$\times$**10**$^{-11}$ **mbar**, were an ice layer is deposited onto a KBr or MgF_2 substrate at **8 K** and can be UV-irradiated (with a flux of **2.5** $\times$ **10**^{14} **photons cm**$^{-2}$ **s**$^{-1}$) and heated in a controlled way up to 300 K.
- The evolution of the solid sample is monitored by in situ transmitance FTIR and UV spectroscopy, while the volatile species are monitored by quadrupole mass spectroscopy.
- The ultraviolet source used for irradiation is a microwave-discharged hydrogen flow lamp (MDHL).



Experimental set-up.

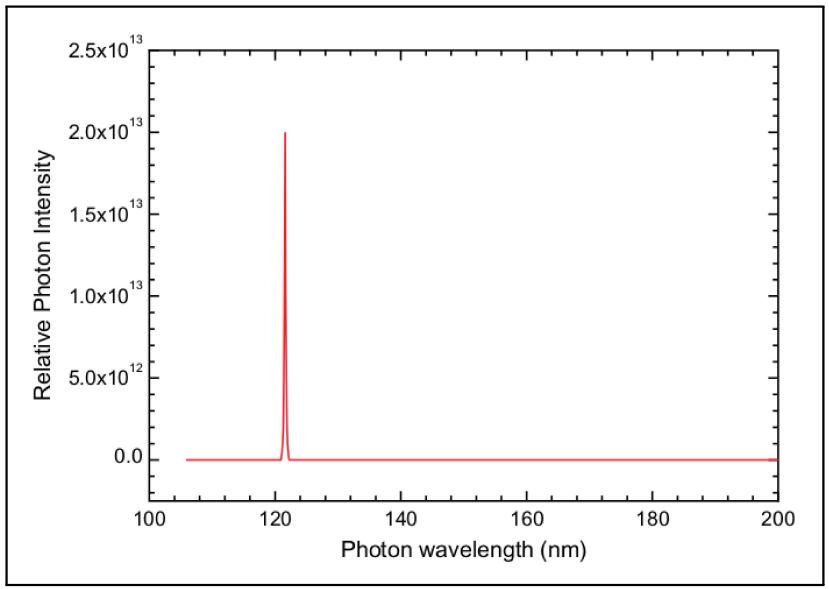
UV-Irradiation

H_2 Lamp



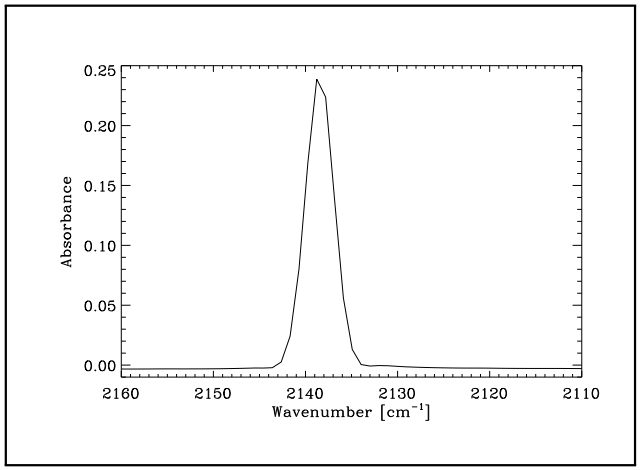
Continuum emission source

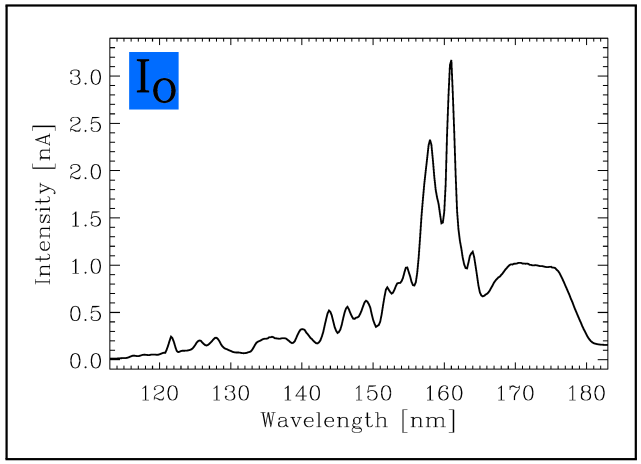
Synchrotron

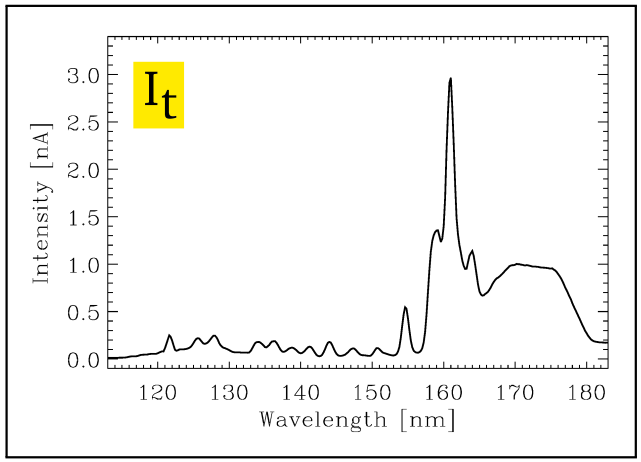


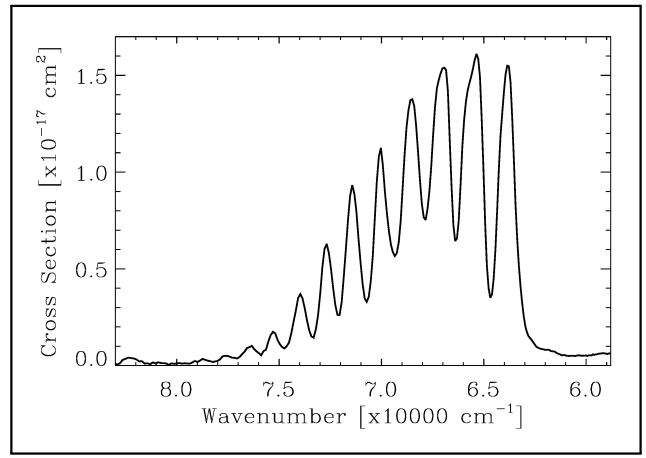
Monochromatic emission source

VUV spectroscopy









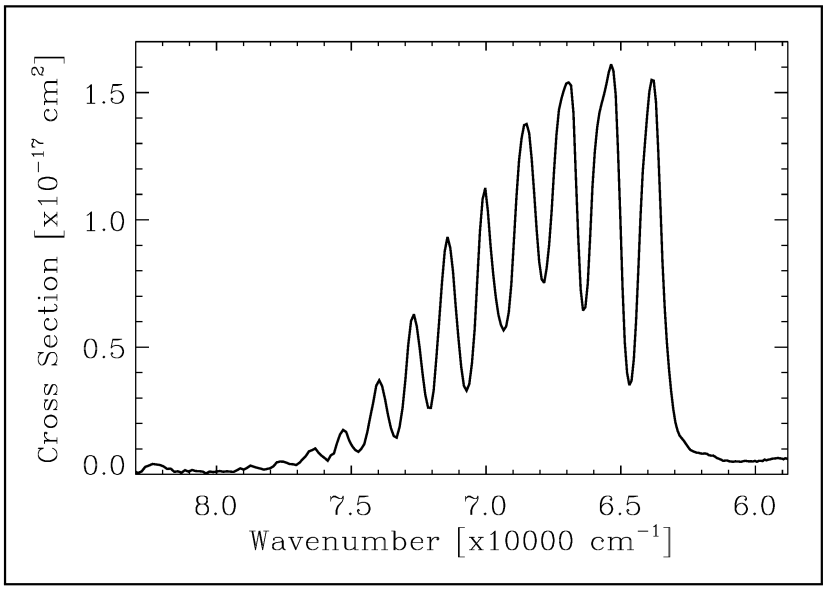
$$N = \frac{1}{\mathcal{A}} \int_{band} \tau_\nu d_\nu$$

$$\sigma(\lambda) = \frac{1}{N} Ln \frac{I_t(\lambda)}{I_0(\lambda)}$$

$$I_t(\lambda) = I_0(\lambda) e^{-\sigma(\lambda)N}$$

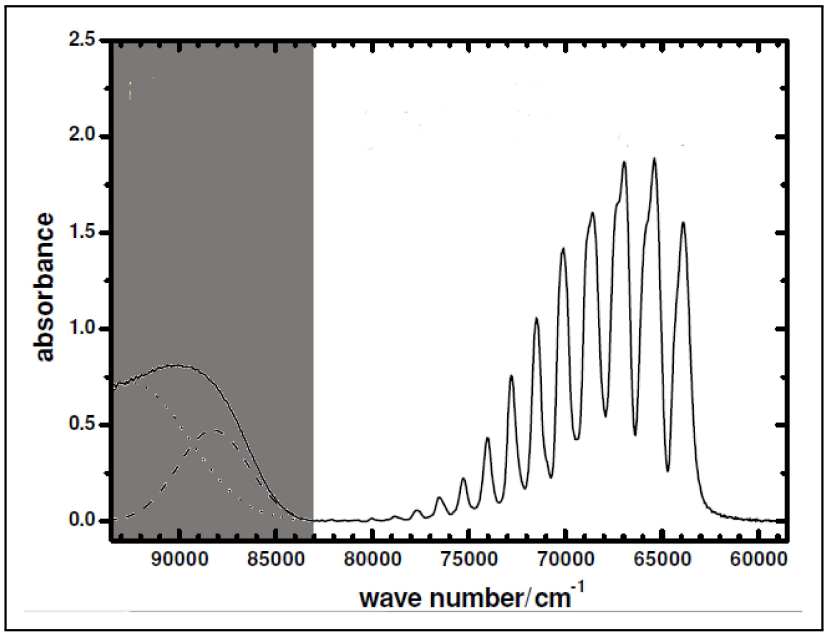
Carbon monoxide - CO

H_2 Lamp



UV-absorption cross section as a function of wavenumber and energy of CO ice at 8K.

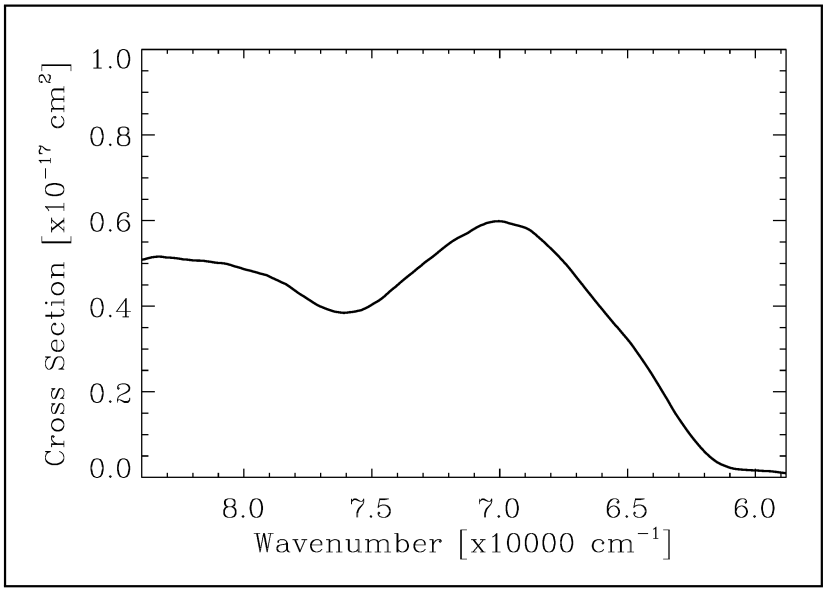
Synchrotron



UV-absorption spectrum as a function of wavenumber of CO ice at 10K, Lu *et* al. 2005.

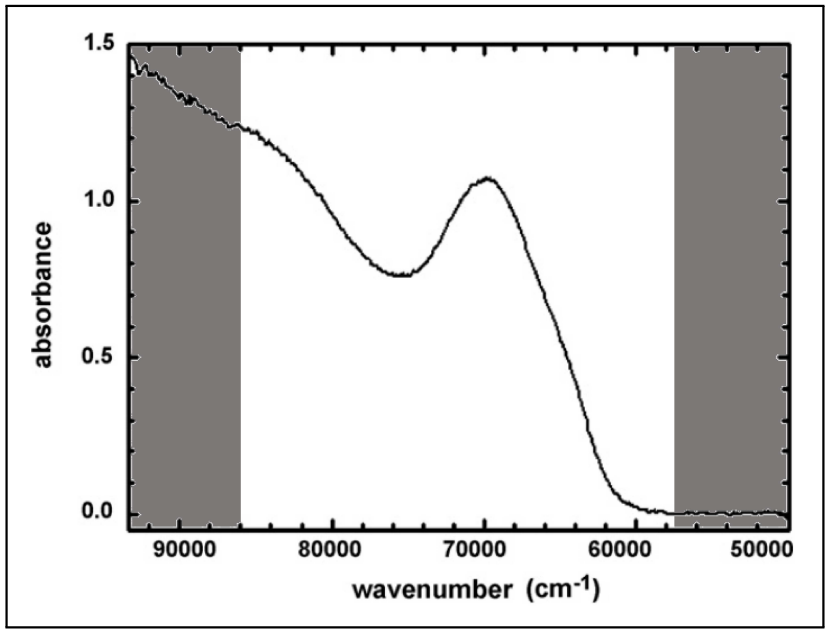
Water - H_2O

H_2 Lamp



UV-absorption cross section as a function of wavenumber and energy of H_2O ice at 8K.

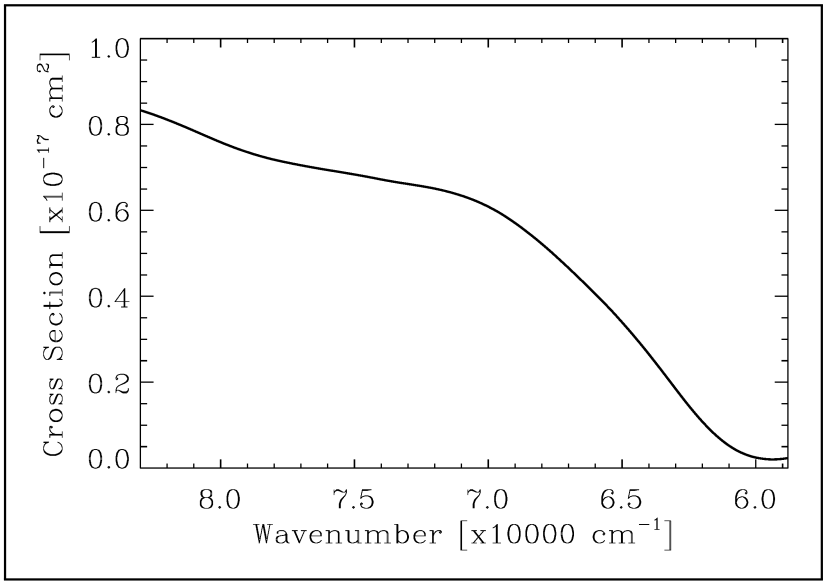
Synchrotron



UV-absorption spectrum as a function of wavenumber of H_2O ice at 10K, Lu *et* al. 2008.

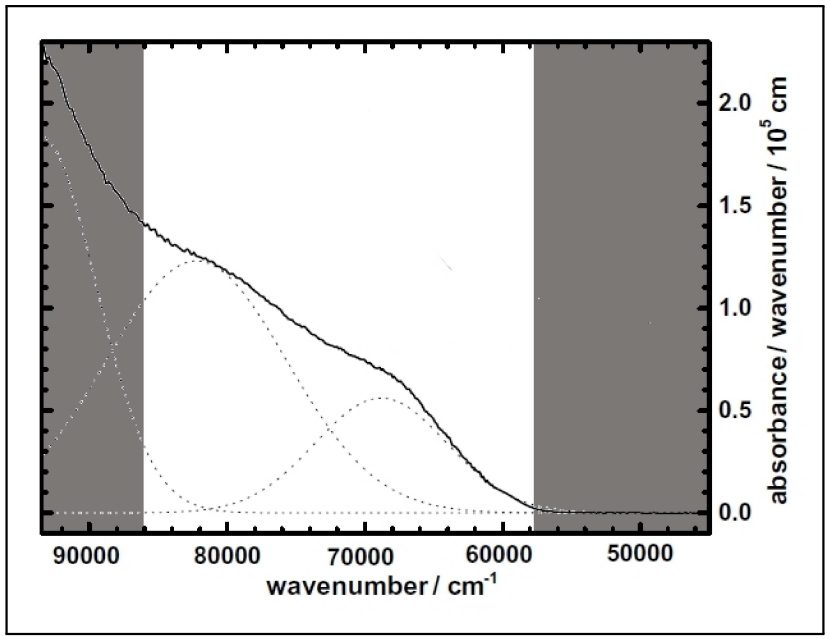
Methanol - CH_3OH

H_2 Lamp



UV-absorption cross section as a function of wavenumber and energy of CH_3OH ice at 8K.

Synchrotron



UV-absorption spectrum as a function of wavenumber of CH_3OH ice at 10K, Kuo *et* al. 2007.

So far...

Known

CO_2

H_2O

NH_3

New measurements

CO

N_2

O_2

CH_3OH

CH_4

H_2S

New isotopologues measurements

D_2O

CD_3OD

$^{13}CO_2$

$^{15}N_2$

Results and Discussion

- We were able to give the UV-absorption cross section of all the species, all of them in a good agreement with the works made by Mason *et al* 2006, Lu *et al* 2005, 2008, and Kuo *et al* 2005.
- The results are pretty satisfactory proving the viability of this new, easy, and cheap way to do UV-spectroscopy.

- This work helps us to understand in which range of the UV-spectrum, and how much UV-photons the molecules absorb.
- These measured UV cross sections can be used in models to predict the behaviour of molecules in the presence of an UV-field like the ones in a star-forming region, and also can be used to a better understanding of the photo-dissociation and photo-desorption processes.

Thanks!!!