Osservatorio Astronomico di Palermo (INAF-OAPa)

First results of the UHV system 'LIFE' (Light Irradiation Facility for Exochemistry)

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Introduction

Dense cloud conditions

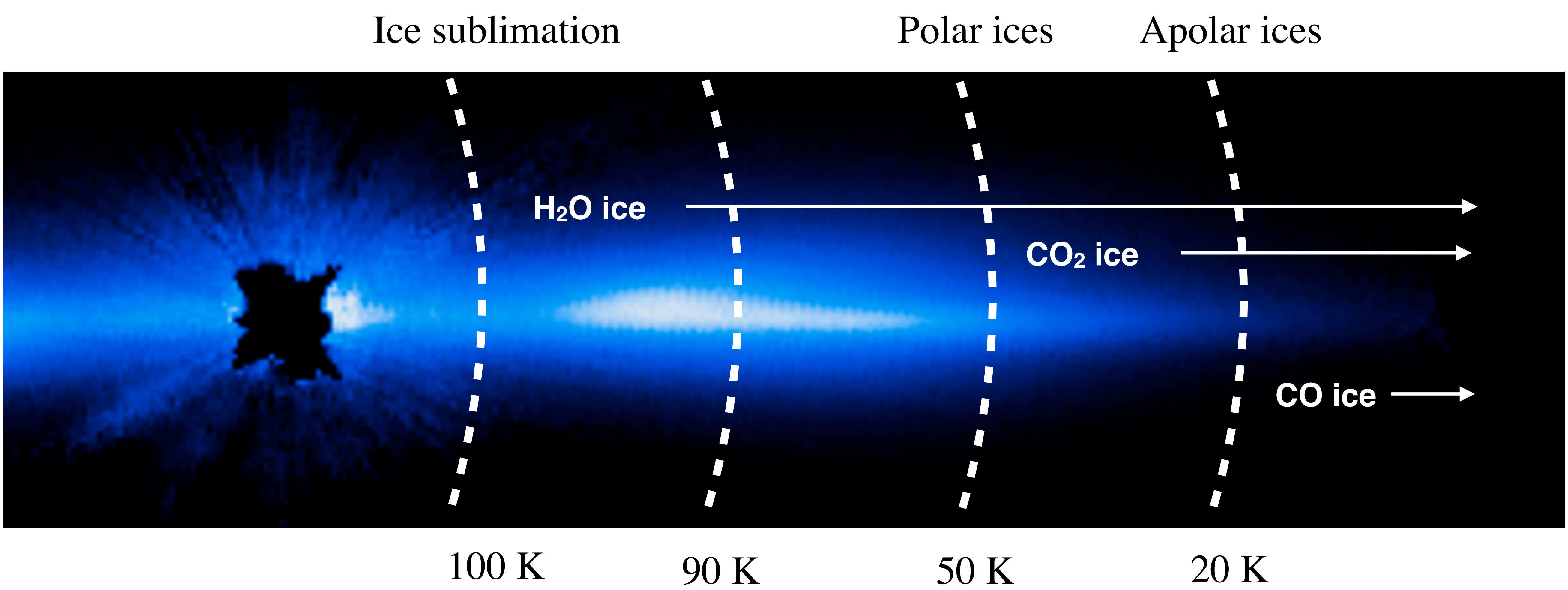
- Density 10^3 - 10^6 particles cm^{-3}, AV > 5, T≈10 K, mostly H_2.
- Star formation regions.
- Molecules in gas phase and dust grains covered by ice mantles.
- Chemistry in ice mantles at T≈10K due to :
  - Surface reactions
  - Photon and ion processing

Interstellar medium (ISM):

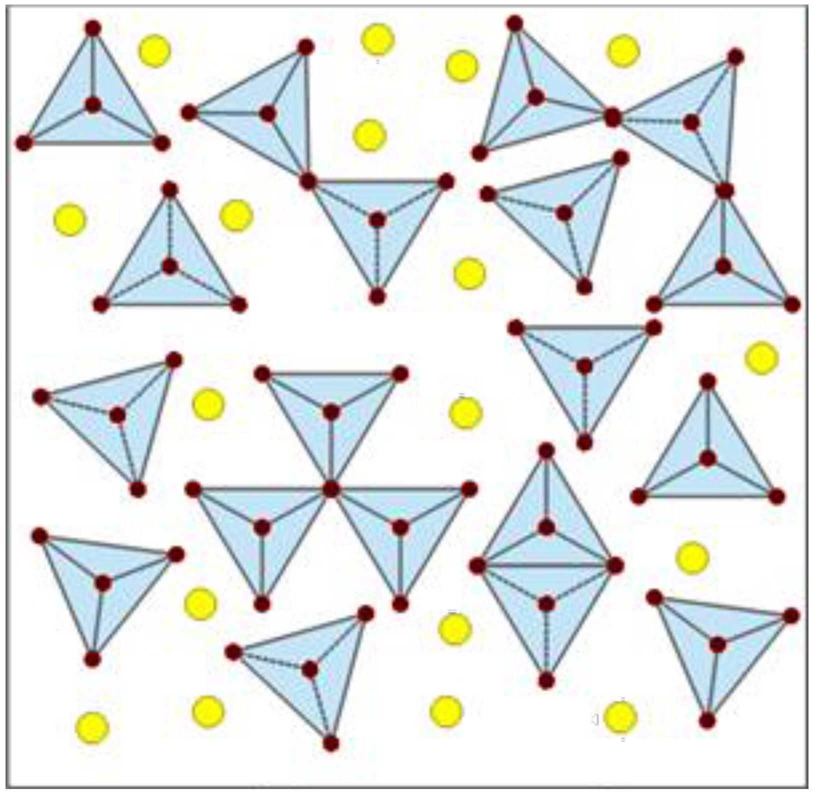
The fairy (Hubble Heritage Team)

Introduction

Circum-Stellar medium.

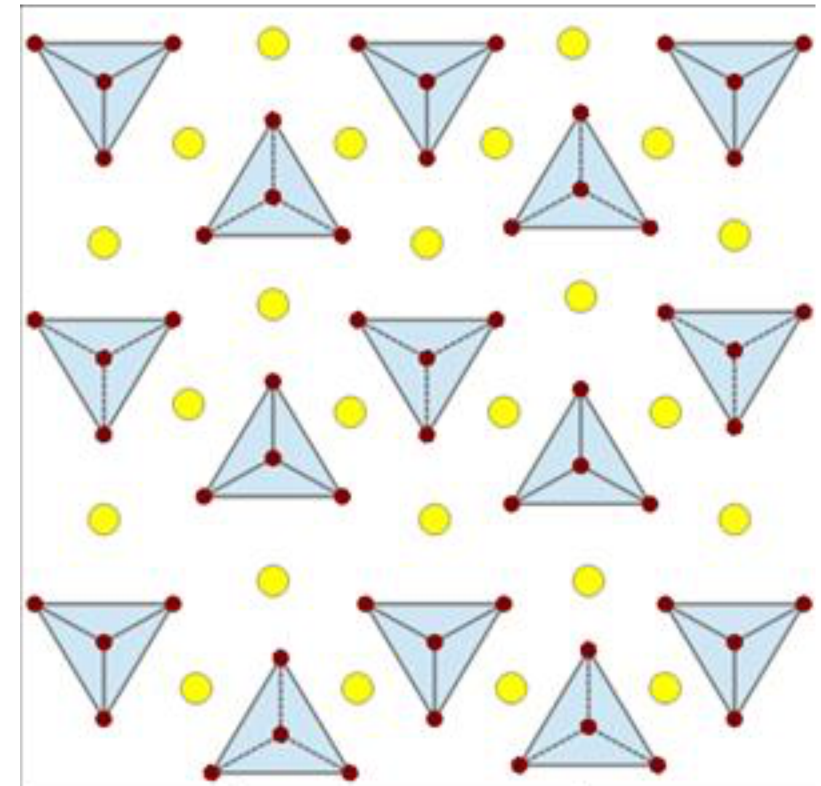


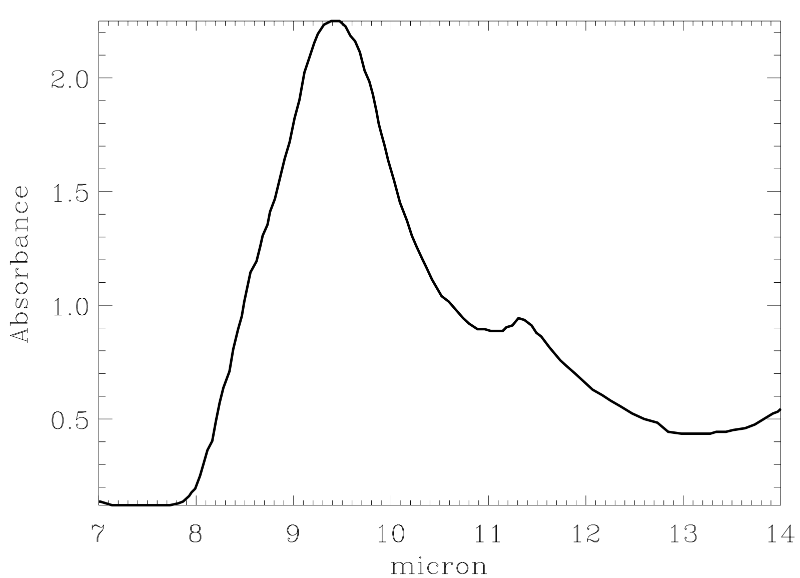
Introduction

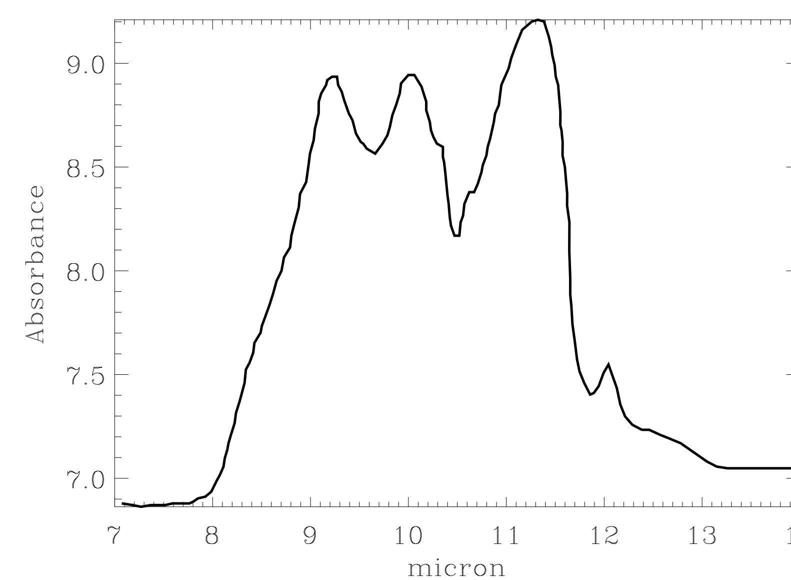


↑↑T

hν, e⁻, ions



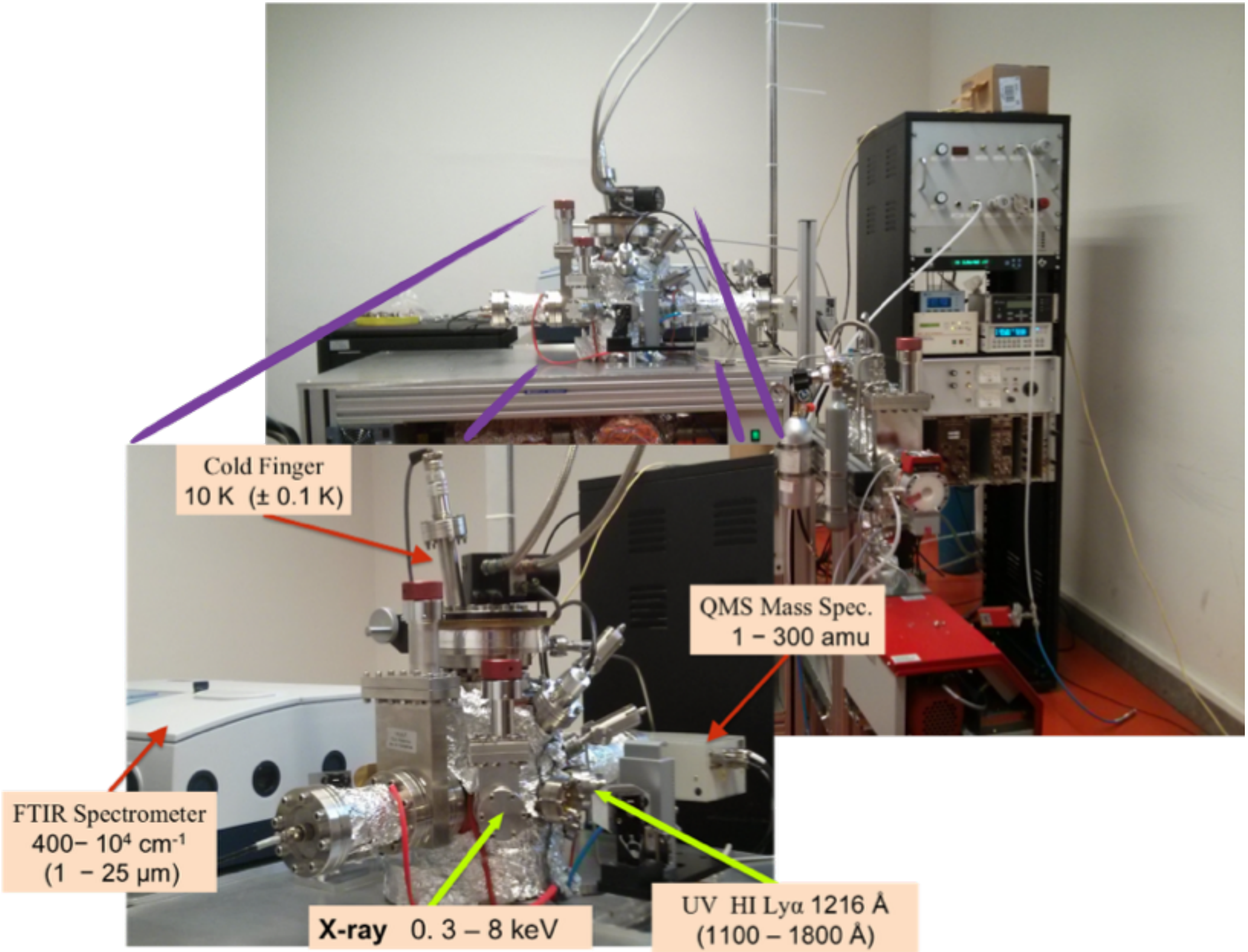




Hallenbeck et al. 1998

Experimental set-up

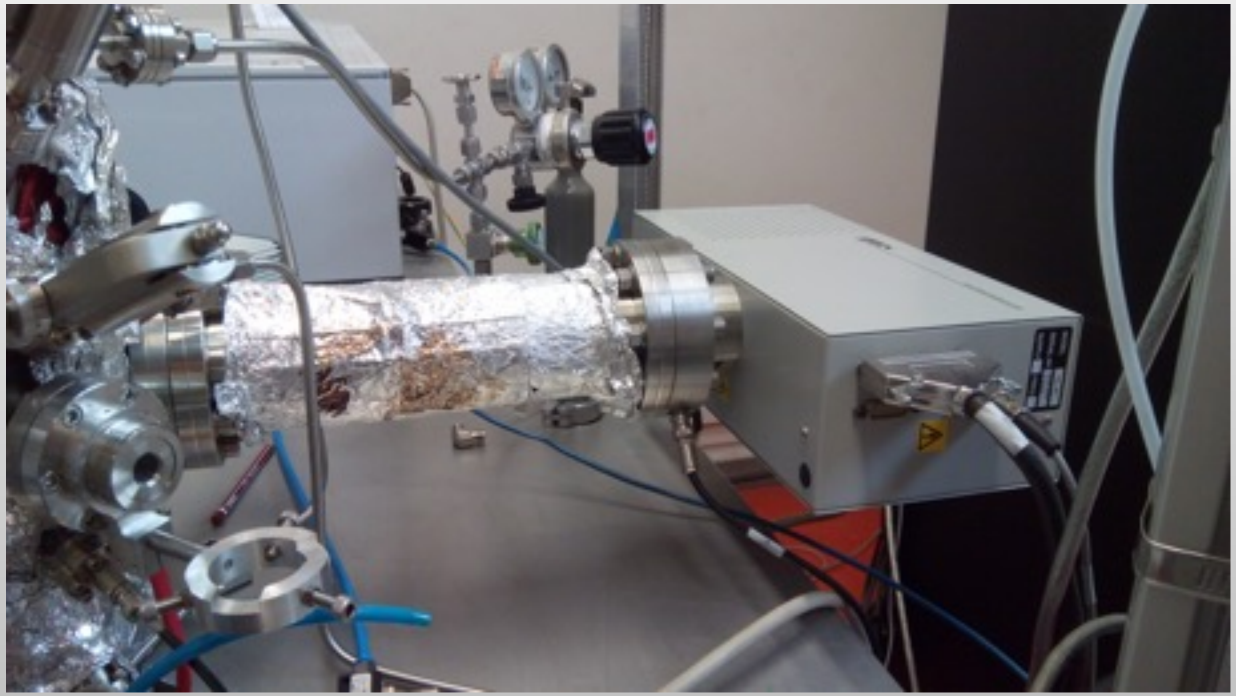
Experimental set-up



Experimental set-up

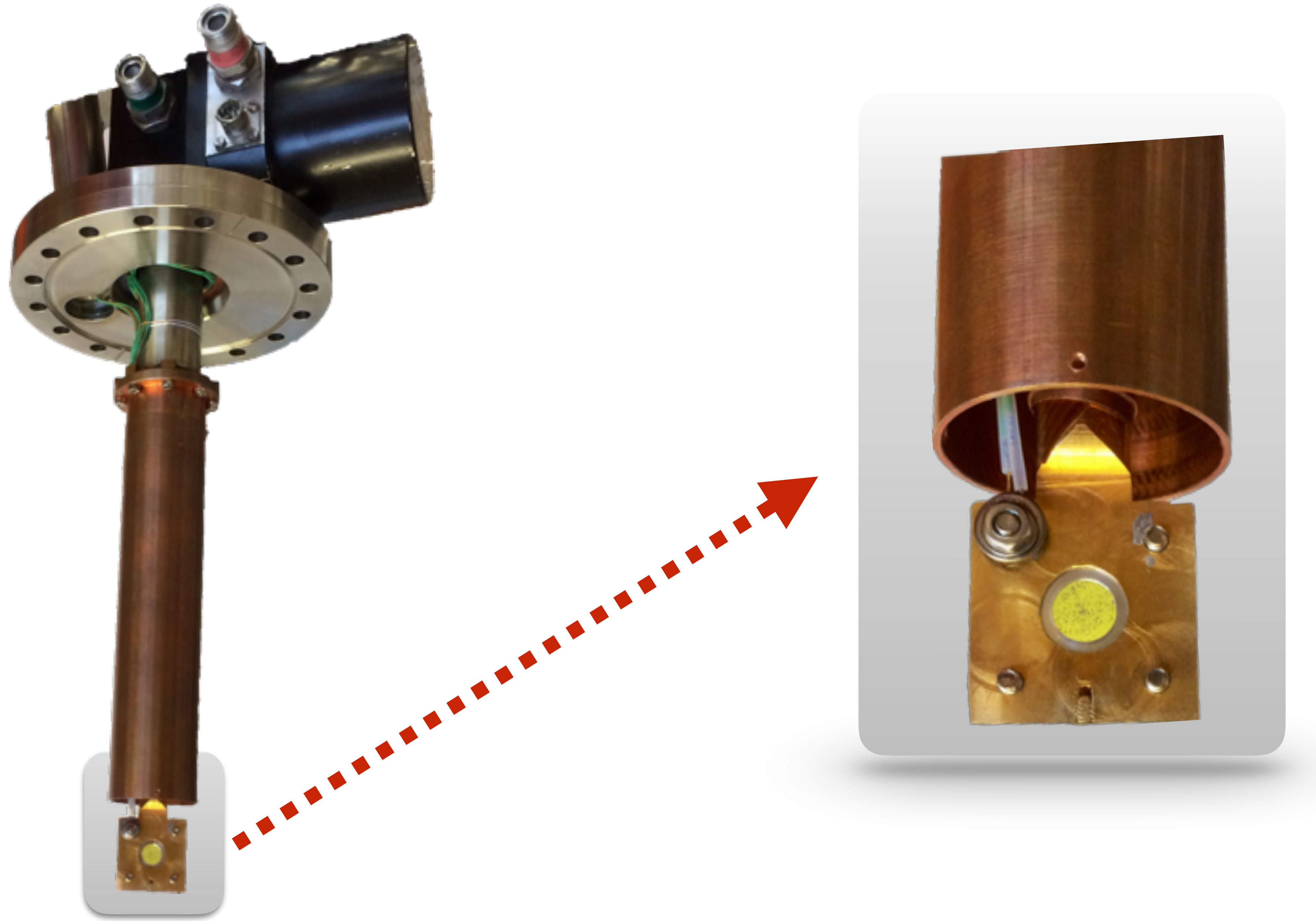
- **Infrared spectroscopy**

- **Mass spectrometry**



Experimental set-up

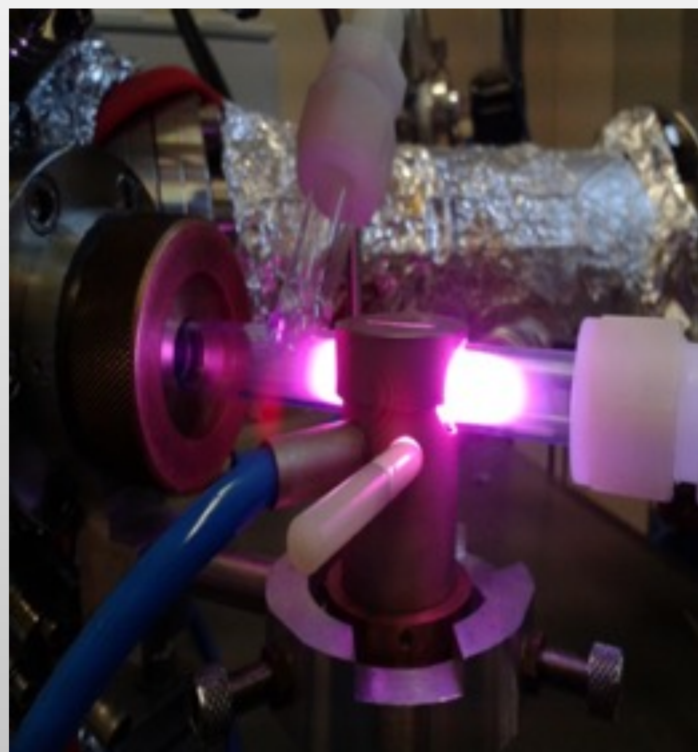
Cooling system:



Experimental set-up

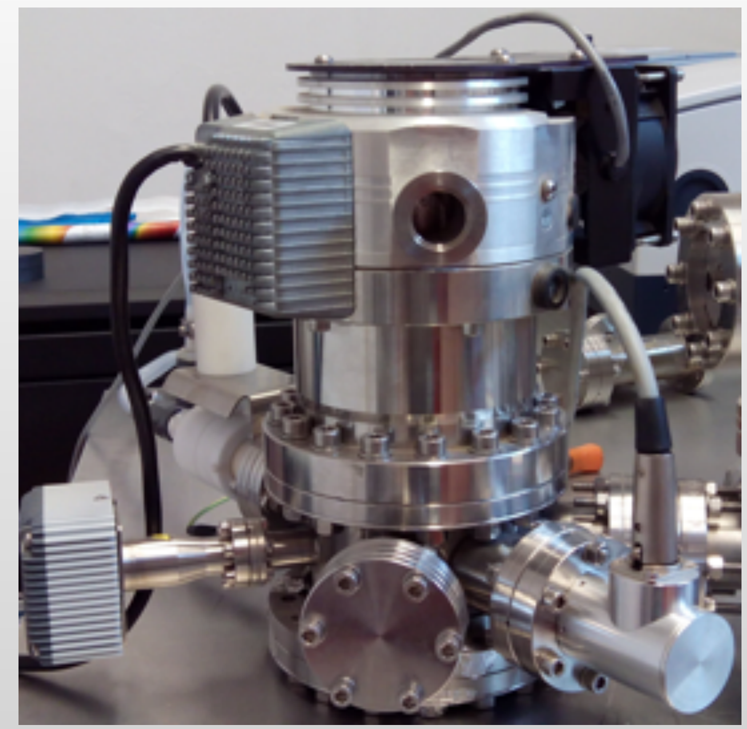
Irradiation sources

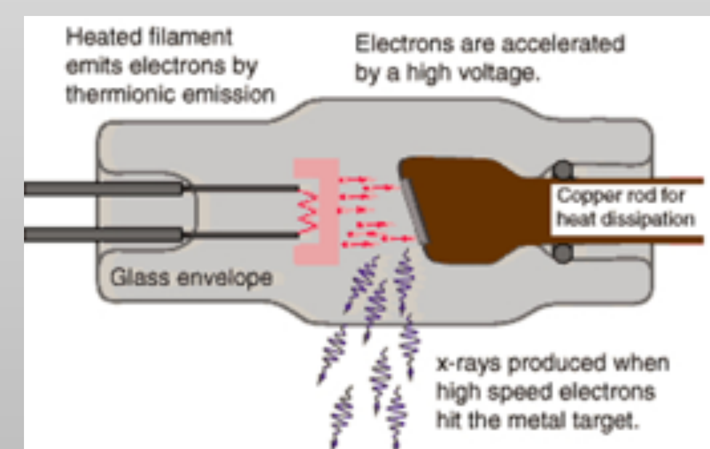
- **UV lamp**



Flux ≈ 3×10^{14} photons s^{-1} cm^{-2}

- **X-ray source**





Flux ≈10^{9} photons s^{-1}

Silicate role on CH_3OH chemistry

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Preprint typeset using LaTeX style emulateapj v. 12/16/11

UV IRRADIATION OF CH_3OH ON SILICATE SUBSTRATES: THE ROLE OF DUST ON THE CHEMICAL EVOLUTION OF ICES

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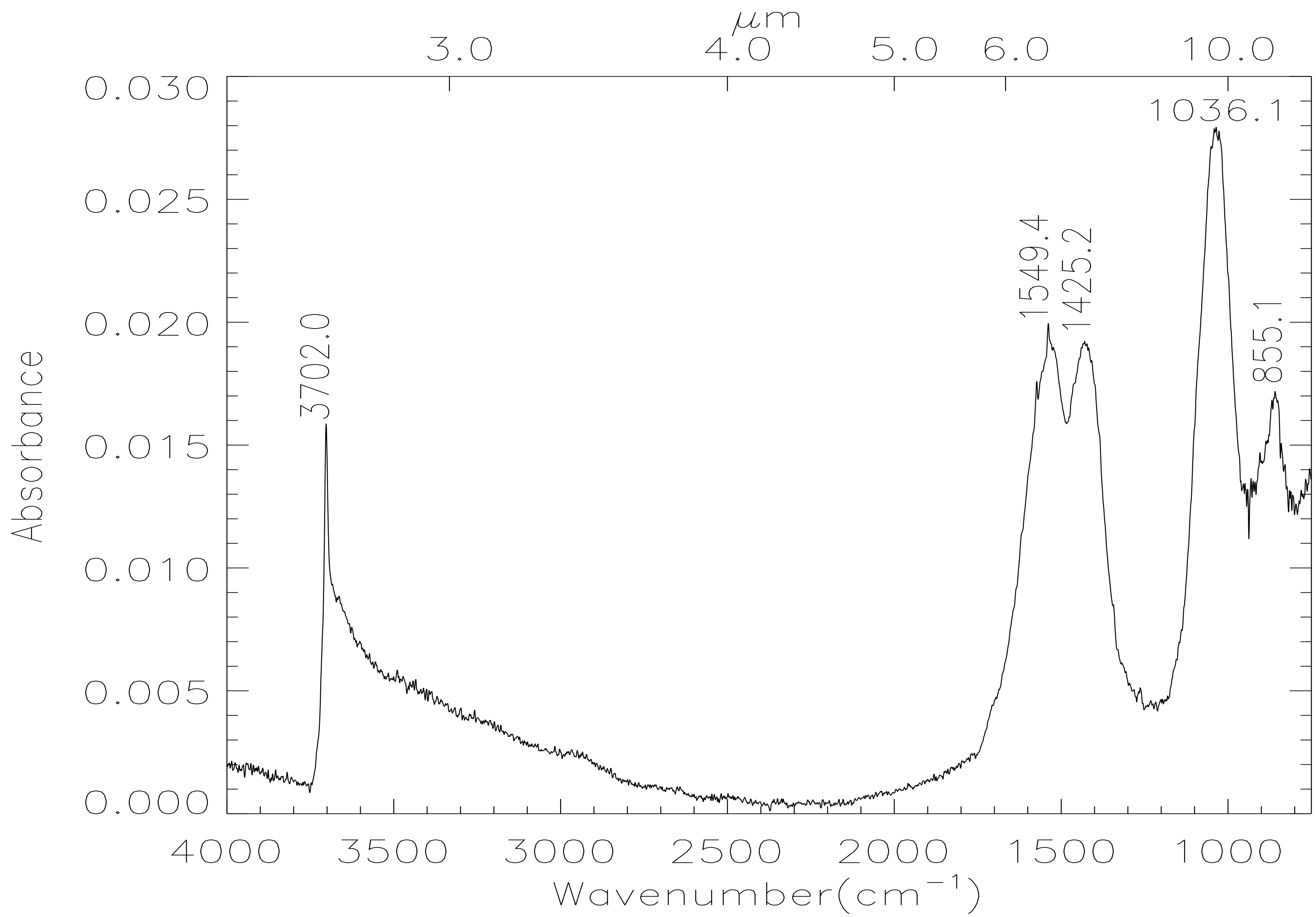
Draft version September 13, 2016

In preparation

Silicate role on CH_3OH chemistry



Infrared spectrum of the silicate, prepared through the sol-gel method. This shows the typical Si-O stretching mode at 9.7 µm. The magnesium carbonate is responsible for the two bands around 7 µm (1500 cm−1) and the band at 11.6 µ (855 cm−1). The peak at about 3700 cm−1 is related to O-H stretching vibrations of isolated Si-OH groups.

Silicate role on CH_3OH chemistry

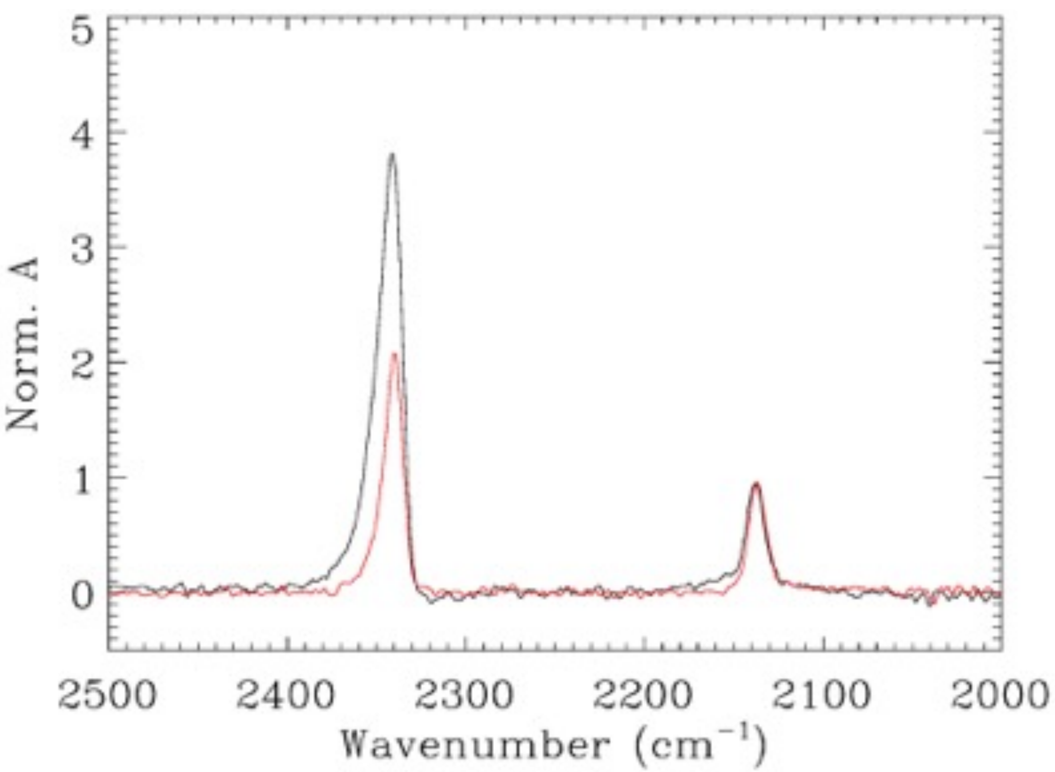
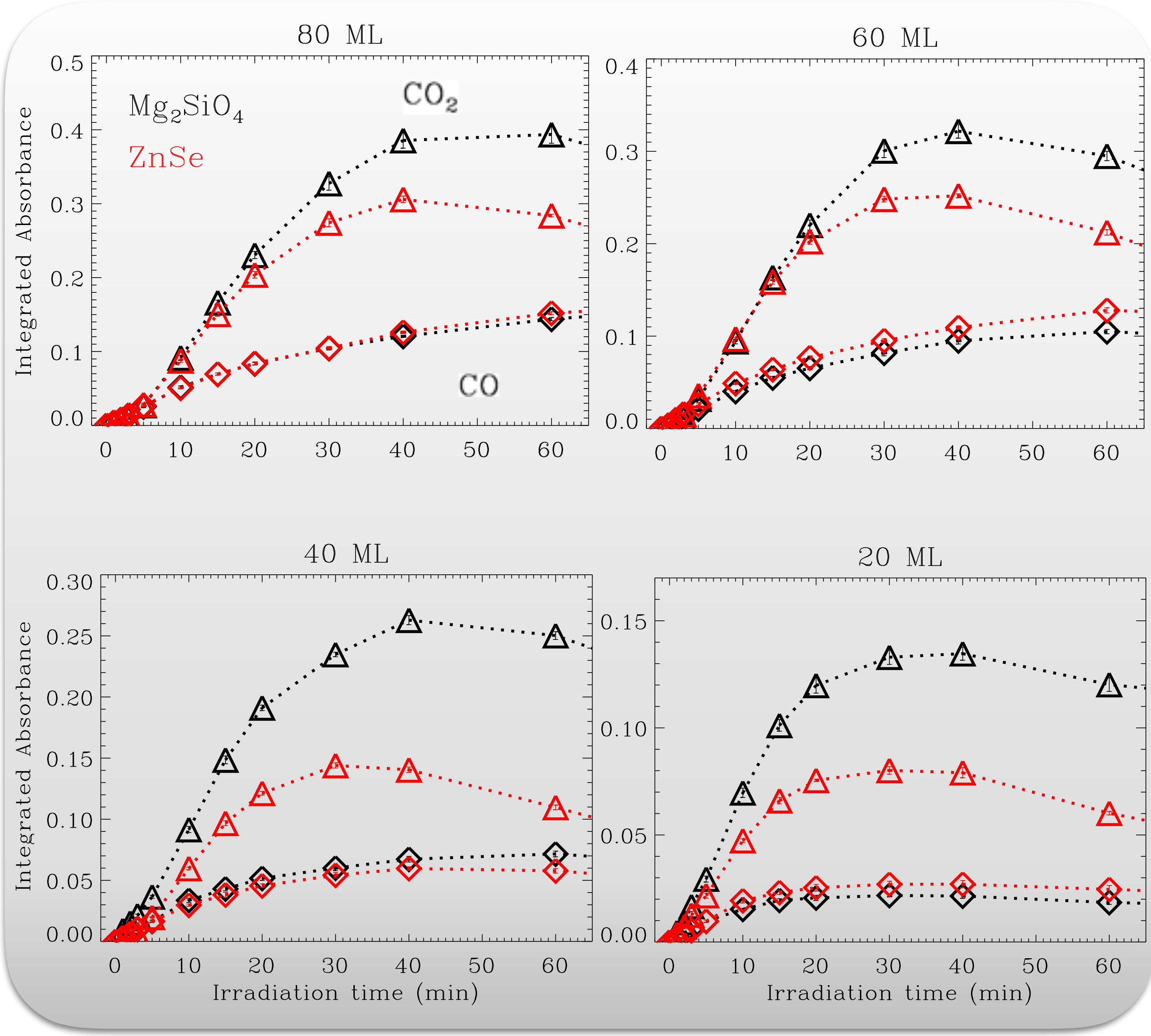
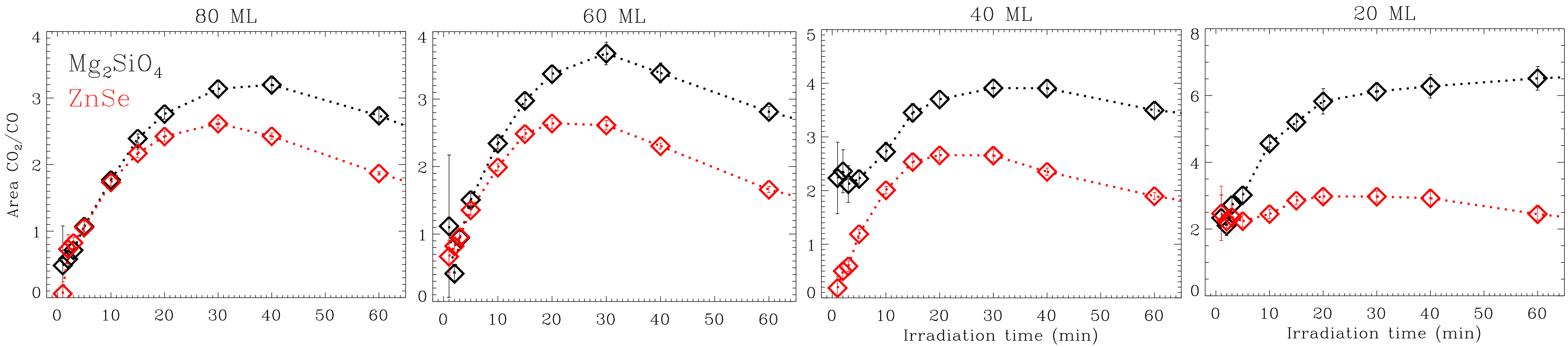
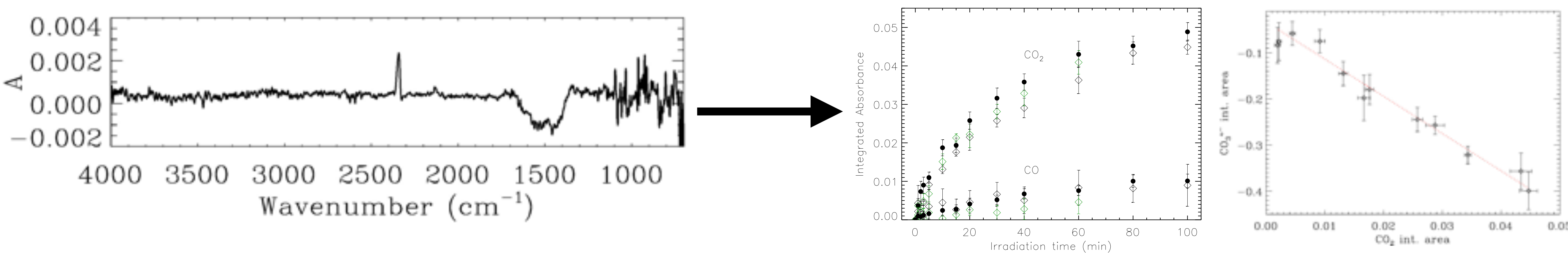


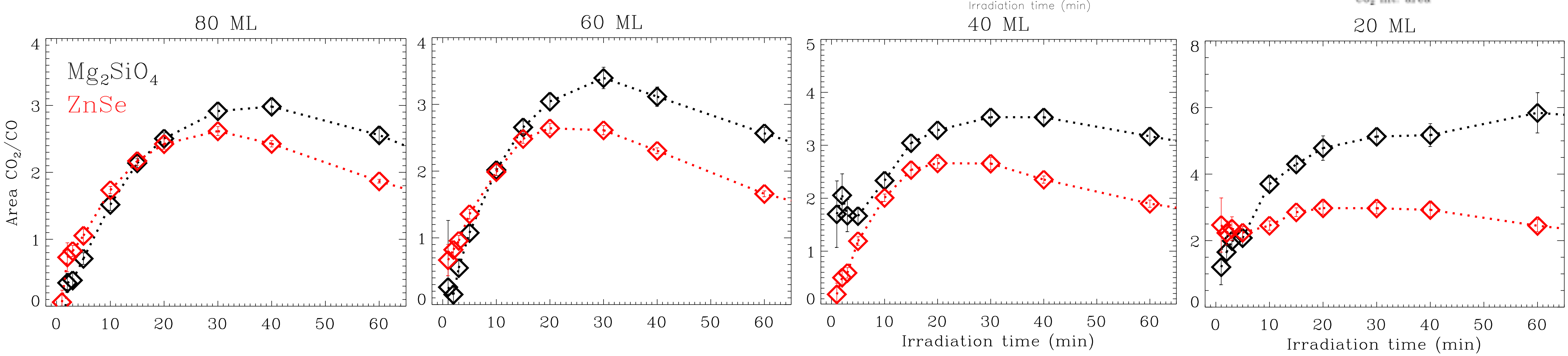
Figure: IR spectra of 20ML irradiation experiment normalized to the maximum value of CO peak at ≈ 2130 cm^{-1}



Silicate role on CH_3OH chemistry







LIFE

Soft X-ray irradiation of Silicates

THE ASTROPHYSICAL JOURNAL, 828:29 (5pp), 2016 September 1 doi:10.3847/0004-637X/828/1/29

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SOFT X-RAY IRRADIATION OF SILICATES: IMPLICATIONS FOR DUST EVOLUTION IN PROTOPLANETARY DISKS

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ABSTRACT

The processing of energetic photons on bare silicate grains was simulated experimentally on silicate films submitted to soft X-rays of energies up to 1.25 keV. The silicate material was prepared by means of a microwave assisted sol–gel technique. Its chemical composition reflects the Mg_2SiO_4 stoichiometry with residual impurities due to the synthesis method. The experiments were performed using the spherical grating monochromator beamline at the National Synchrotron Radiation Research Center in Taiwan. We found that soft X-ray irradiation induces structural changes that can be interpreted as an amorphization of the processed silicate material. The present results may have relevant implications in the evolution of silicate materials in X-ray-irradiated protoplanetary disks.

Key words: evolution – methods: laboratory: solid state – X-rays: ISM

Soft X-ray irradiation of Silicates

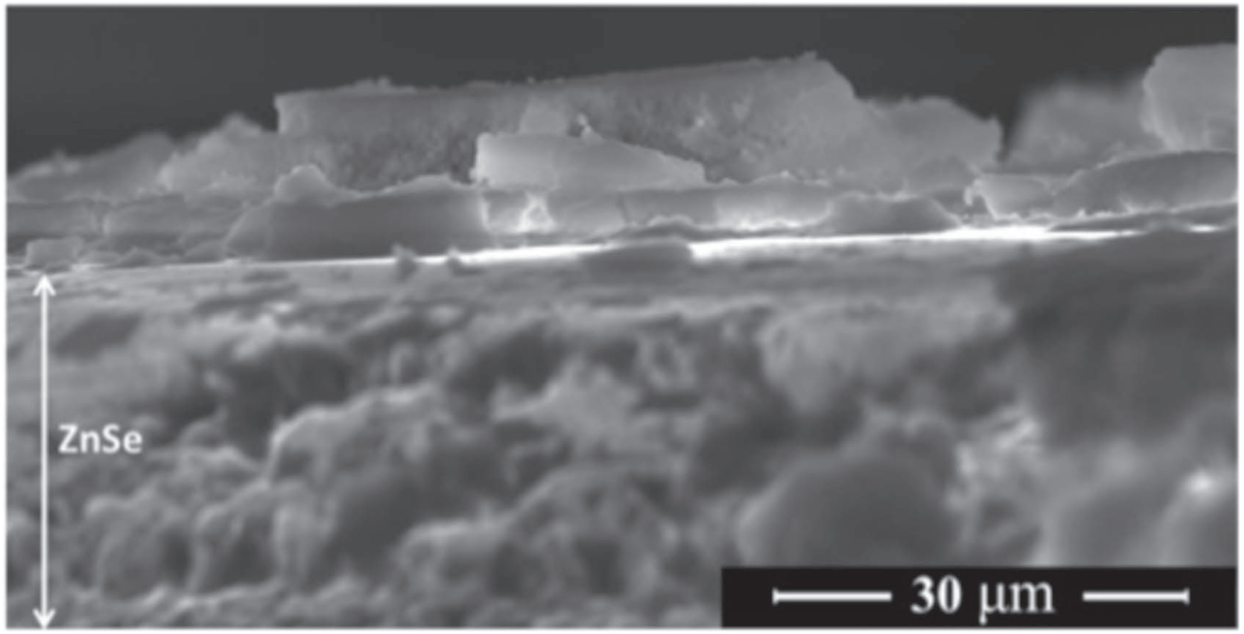


Figure. SEM image of the synthesized silicate. The region marked by the vertical arrow is the ZnSe window onto which the material has been deposited.

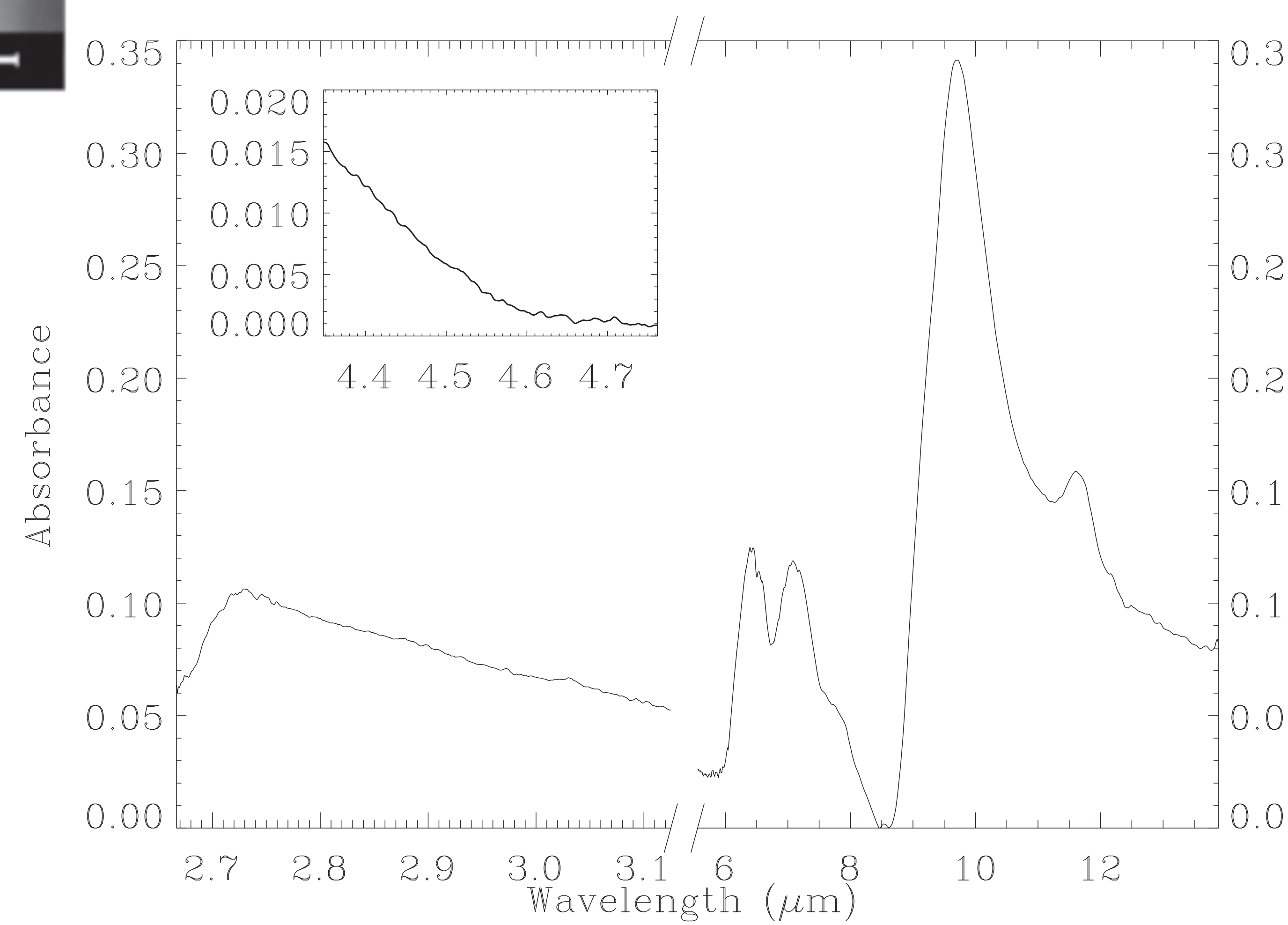
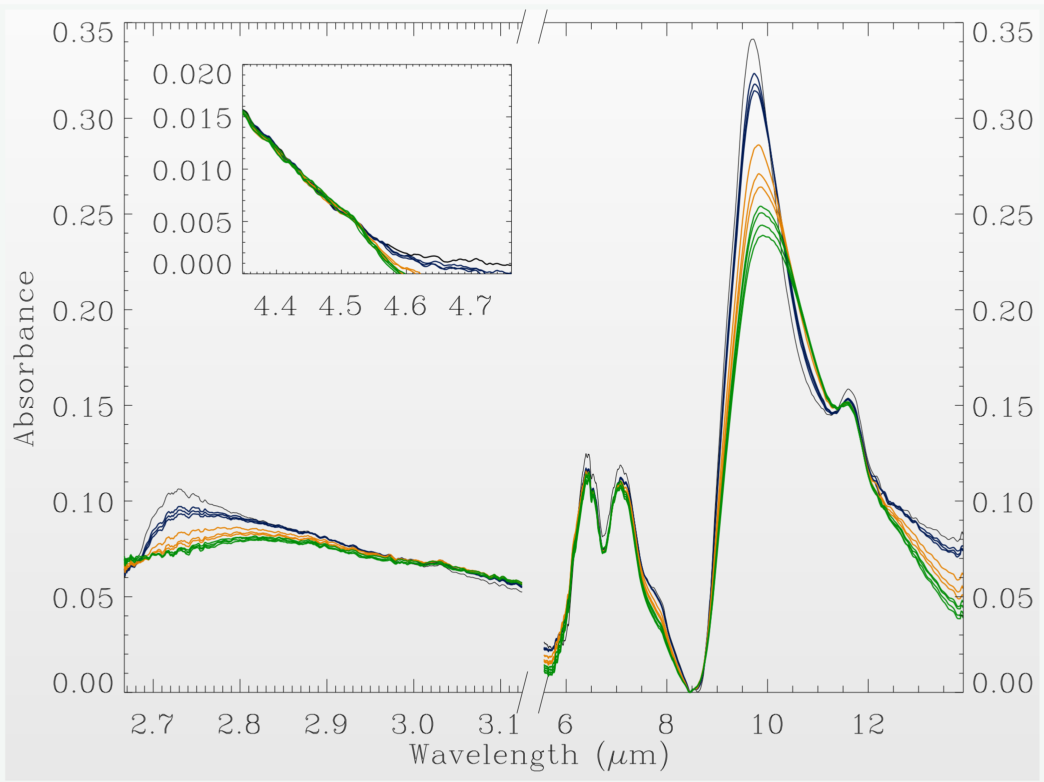
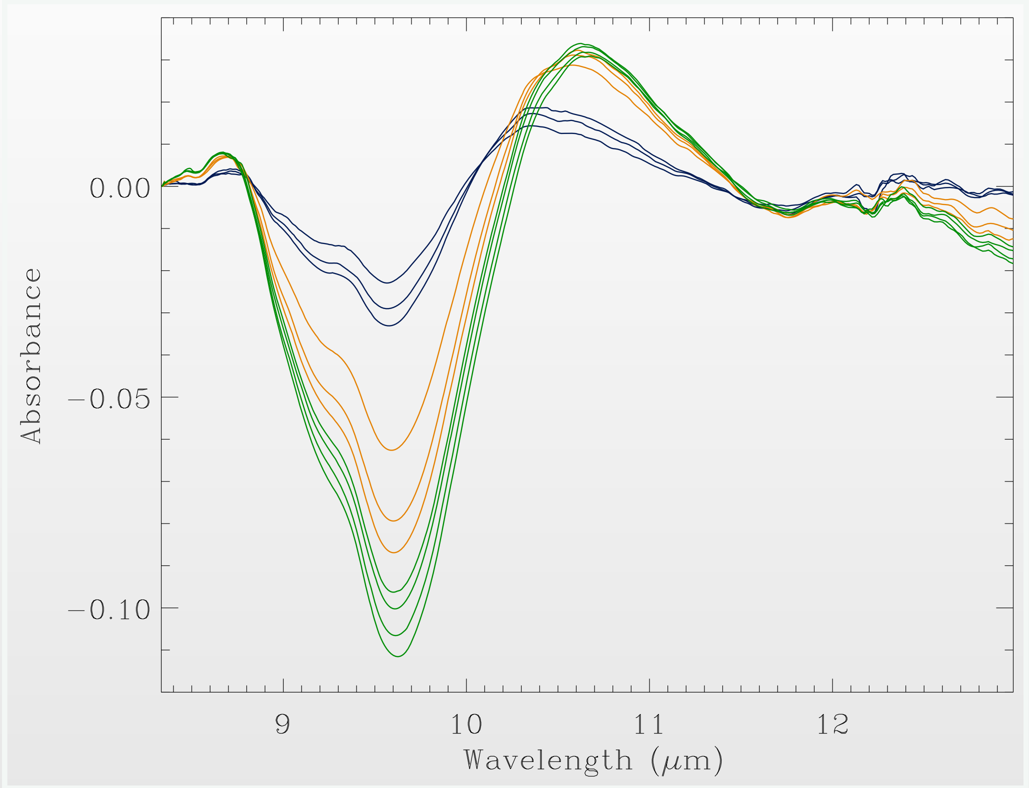


Figure. Infrared spectra of the silicate at 100 K before the irradiation.

Soft X-ray irradiation of Silicates



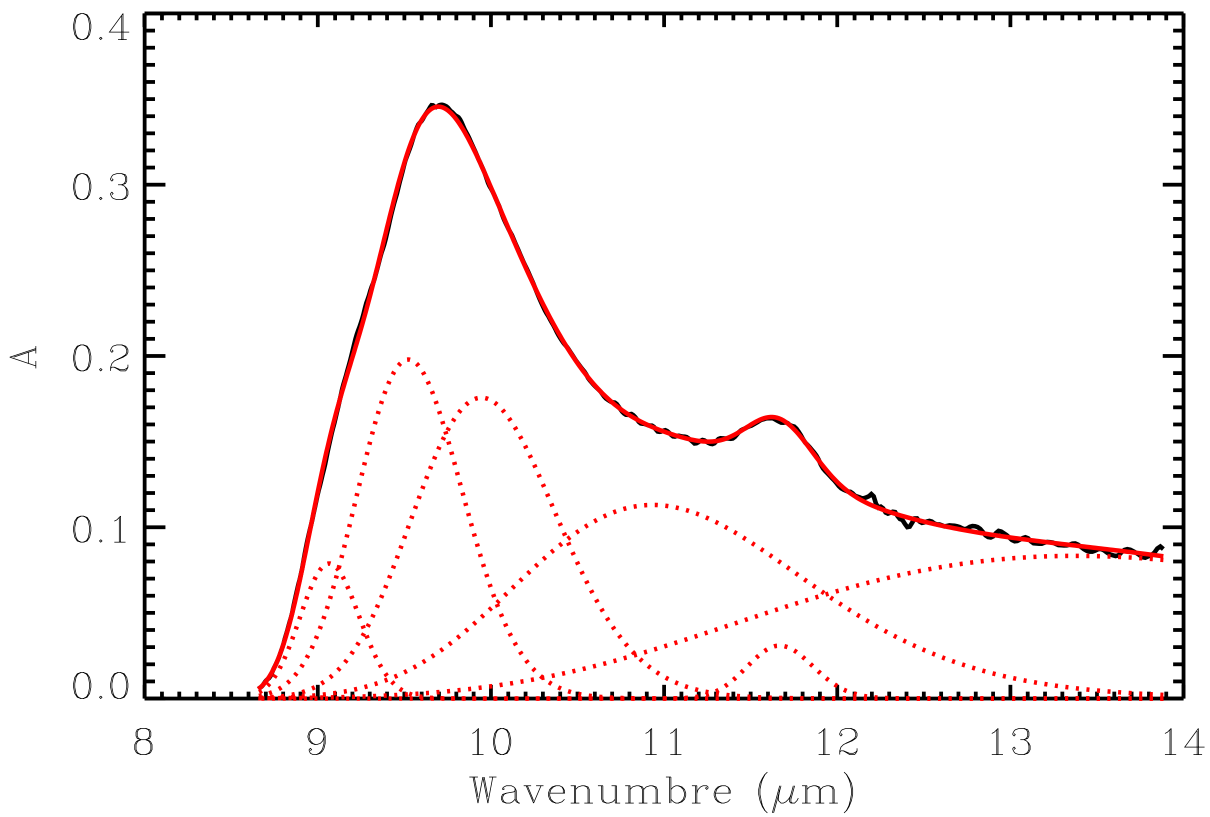


The black line is the silicate spectrum before irradiation. The blue, orange, and green lines are the spectra after the irradiations with weak, medium, and high X-ray rates, respectively.

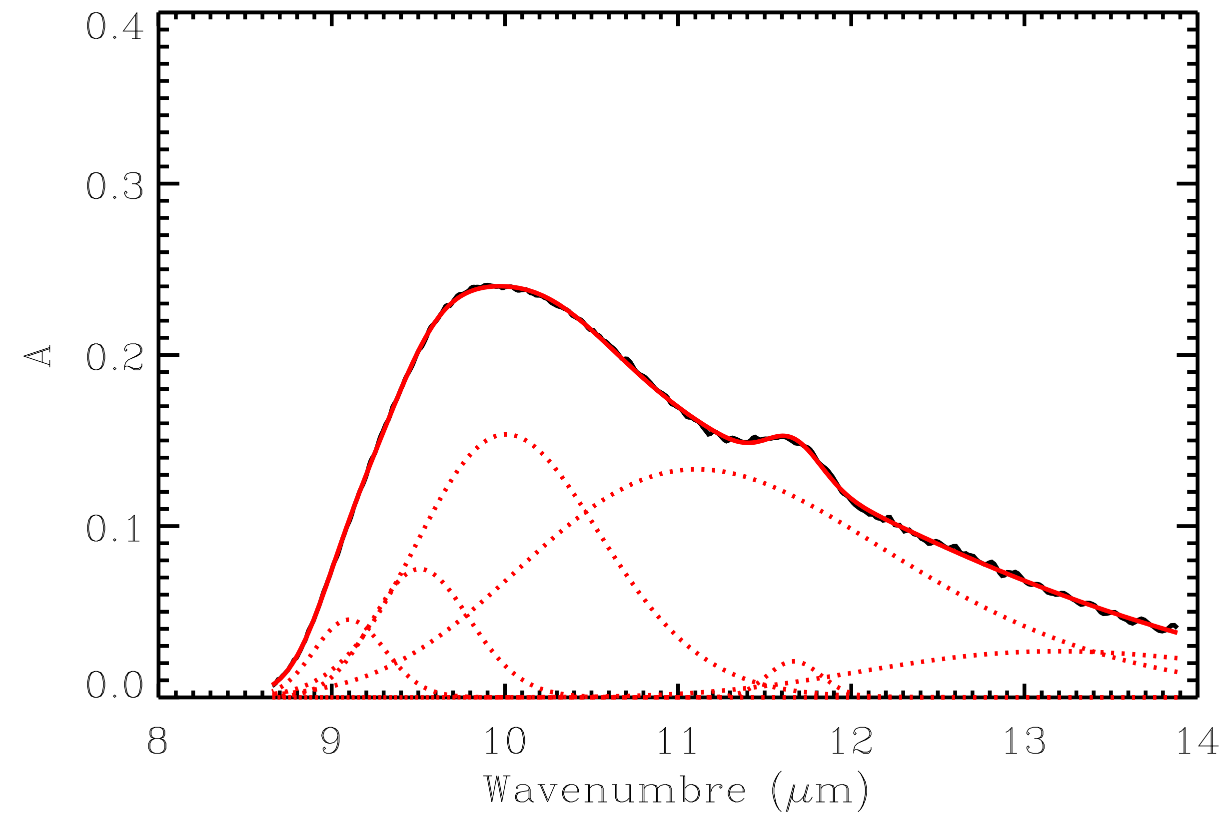
Infrared difference spectra obtained subtracting from the spectra after each irradiation step the spectrum of the silicate sample.

Soft X-ray irradiation of Silicates

- **Sample**



- **After Irradiation**



The best fit of the 9.7μm band was obtained with six components. The components at ~9 and 9.5 μm decrease with the irradiation time, while those at ~9.9 and 10.9μm increase, becoming about 25% wider at the end of the irradiation.

Final remarks

- An increment of CO_2 formation was observed over Mg_2SiO_4 substrate.
- Part of this CO_2 excess could be justified by $MgCO_3$ decomposition
    - $MgO + CO_2 \longrightarrow MgCO_3$
    - $MgCO_3 + h\nu \longrightarrow CO_2 + MgO$
- Catalytic effect of Mg_2SiO_4?
- Soft X-ray irradiation does modify the structure of the silicate sample. We thus interpret the variations as a loss of the residual order of the silicate sample rather than a local ordering due to thermal annealing.
- The observed effect is not related to the occurrence of overlarge local electron densities. We explored two orders of magnitude in the X-ray photon rate and we did detect changes in the band profile even for the lowest irradiation step.