HIGH RESOLUTION VACUUM ULTRAVIOLET ABSORPTION SPECTROSCOPY ON THE DESIRS BEAMLINE @ SOLEIL
29 beamlines
• The DESIRS beamline

• Absorption spectroscopy in the UV-VUV
  • The VUV-FTS branch
  • Spectroscopy of Radicals : OH
  • … and atoms : XeII

• Conclusion
Valence-shell excitations in the gas and condensed phase (5-40 eV)

1. High resolution spectroscopy: VUV-FTS
   • CO, CO₂, N₂, H₂, HD, D₂, He, C₂H₄, C₂H₂ etc…
   • Transient species.

2. Spectroscopy, fragmentation and reactivity of state-selected ions: DELICIOUS

3. Tandem Mass Spec: SRMS2

4. Chemical reactivity: ion/neutral, neutral @ RT, cold neutrals

5. Photoionization dynamics (AR-PES/ i2PEPICO): DELICIOUS
   • cold molecules, laser-excited species, clusters, nanoparticles

6. Dichroism & chirality: DELICIOUS
   • gas phase (PECD, CDAD), condensed matter/homochirality

7. Excitation and relaxation in the condensed phase

35 % of the proposals are astro-related: astrophysics, astrochemistry, astrobiology
The DESIRS beamline

FTS branch

DELICIOUS
SRMS2 – ion trap

Gas filter
VUV-FTS: Principle for a scanning WD interferometer

- Fixed reflector
- Mobile reflector
- VUV source
- VUV photodiode
- HeNe beamsplitter
- Mirror
Various set-ups for the production of transient species

A photo-induced Xe plasma is generated in the DESIRS beamline gas filter.

The synchrotron beam is producing the plasma, and is recorded downstream by the FTS.

A windowless DC discharge installed in-vacuum in the environmental sample chamber of the FTS experimental branch.
Production of the OH radical inside a windowed RF discharge cell

In collaboration with B. Gans et al. (ISMO), JC Loison et al. (ISM), A. Heays

OH spectrum from H₂O + He

Linewidth = 0.27 cm⁻¹ (resolving power ~ 300000)
dOH ~ 1.5x10^{13} cm⁻³
Experimental and theoretical OH $D^2Σ^-(v'=0) \leftarrow X^2Π (v''=0)$ band f-values

<table>
<thead>
<tr>
<th>$f_{v'v''}$</th>
<th>Reference</th>
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<tbody>
<tr>
<td>0.0135(10)</td>
<td>This work (a)</td>
</tr>
<tr>
<td>0.008-0.013</td>
<td>Experiment (b)</td>
</tr>
<tr>
<td>0.015</td>
<td>Experiment (c)</td>
</tr>
<tr>
<td>0.012</td>
<td>Calculation (d)</td>
</tr>
<tr>
<td>0.013</td>
<td>Calculation (e)</td>
</tr>
</tbody>
</table>

(a) A.Heays et al., JQSRT, 204, 12 (2018)  
(b) Lee et al., J. Chem. Phys. 81, 31 (1984)  
(c) Chaffee et al., Astrophys. J., 213, 394 (1977)  
(g) De Beer E. et al. JCP 94, 7634, (1991)  
(h) Van der Loo and Groenenboom JCP,123,74310 (2005)

From line broadening a 20 ps lifetime was determined a

- Compatible with a laser-based lifetime measurement f : < 8ns
- Incompatible with a REMPI measurement for low J g : > 500ps /J(J+1)
- A factor 5 shorter than a published theoretical prediction h : 100 ps
Local perturbation of OH $D^2\Sigma^-$ (v=0)

The $D$-state interacts with various repulsive excited-states, see Van der Loo et al. (J. Chem. Phys., 123, 74310, 2005).

However, this does not explain the observed localized width peak and shifted energy levels of OH $D(0)$ near $N = 3$ and $4$ that would rather be the sign of a bound level in the vicinity of D(0). For a more detailed discussion see: A.Heays et al., JQSRT, 204, 12 (2018)
In this case, the OD band is completely entangled into a strong structured band from the precursor D$_2$O. The high spectral resolution spectrum gives access to the unambiguous radical signature.
Two undulator spectral windows recorded near the $^3P_2$ ionization limit
- spectral resolution: 0.27 cm$^{-1}$ (blue trace) and 0.43 cm$^{-1}$ (red trace)
Astrophysical application: Observation in the visible of Xe\(^+\) transitions from HgMn stars*

Identification of the lines using the FTS or the NIST levels

*Yuce et al. (2011) Astron Astrophys A37, 528
Xe$^+$ - calculation using the COWAN code*

76 transitions are still unattributed

Absolute scale propagated from the 5s5p$^6$ 2S transition oscillator strength (Lauer S et al., J Phys B At Mol Opt Phys 32, 2015, 1999)

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*Cowan Code: 50 Years of Growing Impact on Atomic Physics, https://doi.org/10.3390/atoms7030064
Summary

• High resolution and sensitivity: UV-VUV absorption is a powerful tool for gas phase

• Complete the Xe\(^+\) data analysis

• Project: collaboration with the LPSC (Grenoble) → Time resolved VUV-FTS for plasma diagnostics

2 calls per year:
mid-February & mid-September

http://www.synchrotron-soleil.fr/
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Thank you for your attention