FOCUS ON

AILES/Ultra-high vacuum group: a long-path cryogenic cell for IR absorption

The AILES beamline, which exploits the brillance of SOLEIL for spectroscopic analysis in the infrared (IR) field, has linked up with the Ultra-High Vacuum Group and LISA[1], to develop the first long-path cryogenic cell for the quantitative analysis of gas in the IR - THz[2].

IR spectroscopy plays a key role in the remote sensing of molecules in inaccessible environments (plasmas, combustion, astrophysics, etc.) or for the quantification of molecules in the atmosphere. The interest of the scientific community has motivated the development of a long-path cryogenic gas cell. Low temperature measurements are used to study these molecules in situ or even to depopulate the excited vibrational or rotational levels, an essential prerequisite for analysis and modeling.

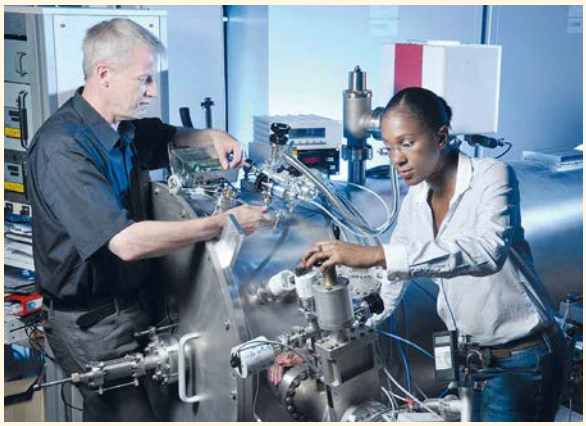
The aim was to have a cryogenic gas cell, homogeneously cooled, compact enough to be used on the AILES beamline but capable of generating optical paths over one hundred meters long. A specific device was developed, optimized for both the mid and far IR ranges, allowing easy switching between these two ranges on the same samples or a rapid change of optical path, while being compatible with oxidizing or halogen gases. Such an instrument is unique, as far as we know.

Cryogenics and IR optics, a long-pathway and stability: conflicting demands...

Many challenges had to be met: in addition to obtaining a long optical path, the distance light traveled had to be controlled between 3 and more than 140 meters, but also at temperatures between -190 and +100°C, with a perfect seal and the use of materials resistant under vacuum and to the gases to be studied, IR optics compatible with low temperatures, together with ultra-high vacuum and cryogenic systems that do not generate any acoustic vibration. With solutions relying heavily on vacuum technology, a close collaboration developed between the AILES group and the Ultra Vacuum Group. Other skills present at SOLEIL were also mobilized: the Design/Engineering Group for the mechanics and modeling of thermal constraints, together with the Pulsed Elements Group for electronic wiring.
In addition to the commitment and skills of SOLEIL, a key element of success has been the ability to rely on the technical expertise of local industrial partners: the mechanical precision design of the quadruple cryogenic cell (STIM, Cachan), and optics and thin films (MAT Technology, OPTIMASK, Morangis).

A need for precision metrology...

One specific requirement was for the development of a pressure sensor in the sub-millibar range, for accurately measuring the pressure of the gases for which the profiles and IR absorption cross-sections are being determined. Such a device was developed at SOLEIL in collaboration with the Ultra-High Vacuum Group.



Laurent Manceron and Laetitia Lago setting up the cryogenic cell...

Up and running at the end of 2012!

After more than two years of development and testing, the first measurements were carried out in late 2012[3] and since then there have been increasing numbers of requests for studies on anthropogenic atmospheric gases (SF_6, CF_4, CF_3I, C_3H_8 or volatile organic compounds) in collaborations or as user requests (U. Bourgogne, LISA, U. Aachen, IMK Karlsruhe, etc.)

1. LISA: Laboratoire Interuniversitaire des Systèmes Atmosphériques, CNRS - U. Paris Diderot et Paris Est (contact: Fridolin.Kwabia@lisa.u-pec.fr)
2. Range covered: wavelengths from 2 to 1000 µm
3. See http://www.synchrotron-soleil.fr/Soleil/ToutesActualites/2013/AILES-Modelisation

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