Gas cell development for infrared spectra calibration

Luisa Valdivielso, Pedro Esparza, and Eduardo Martín

Abstract NAHUAL is a high-resolution near-infrared echelle spectrograph of high stability on preliminary phase development for GTC (Gran Telescopio de Canarias). Its natural location is a Nasmyth focus. One of the principal scientific aims is to carry out high precision radial velocity measurements (from 1 to 10 m/s) in the near infrared. To achieve high stability on radial velocity measurements, NAHUAL needs a calibration unit that uses a mixture of gases whose absorption spectra must be as homogeneous as possible between 0.95 and 2.4μm. We report on the measurements done to date with potentially active gas mixtures as acetylene, methane, nitrous oxide or hydrocarbons.

1 Introduction

NAHUAL (Near-infrAred High-resolUtion spectrograph for pLanet hunting) is a high-resolution (R>50000) near-infrared echelle spectrograph for the 10.4-m-GTC telescope. Its principal aim is detection of exoplanets by means of very high precision radial velocity measurements (1-10m/s) [1]. The instrument will include a gas cell for calibration similar to I_2-cell used in the optical regime. We are searching for an optimal gas mixture stable with time and temperature in the instrument operating wavelength range (Y, J, H and K bands) since there is no other pure gas with a wide spectral domain. The instrumental design locates the cell along the stellar beam in front of

Luisa Valdivielso · Eduardo Martín
Instituto de Astrofísica de Canarias, Calle Vía Láctea s/n, E-38200, La Laguna, Tenerife, Spain e-mail: lval@iac.es

Pedro Esparza
Departamento de Química Inorgánica, Facultad de Química, Universidad de la Laguna, Calle Francisco Sánchez,s/n, E-38204, La Laguna, Tenerife, Spain

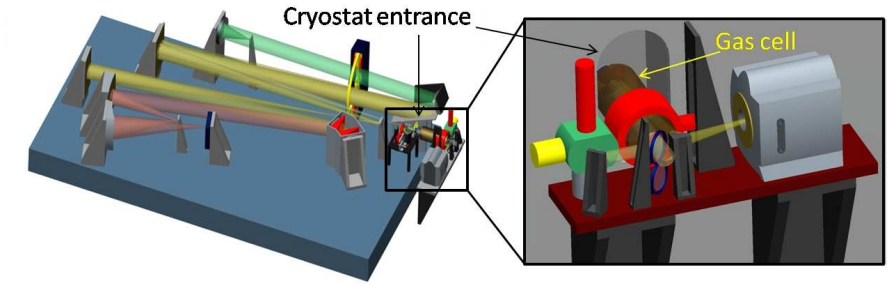

Fig. 1 Conceptual mechanical design of NAHUAL. The molecular absorption gas cell for line calibration is placed outside the cryostat.

the spectrograph (see Fig. 1). Thus, we have the stellar spectrum superimposed to the absorption spectrum (perfectly characterised) for simultaneous calibration.

We present preliminary results of laboratory experiments of different gas mixtures done to date.

2 Laboratory mixtures

The gases are mixed in a controlled high vacuum chamber (N_2), with manual manometric control using a mercury column. Previous vacuum to the cell, different partial pressures of each gas are injected and the mixture is completed with Helium gas up to atmospheric pressure.

3 Laboratory measurements

Since 2005 we have done 48 laboratory measurements over 28 different potential gas mixtures in the 0.8-2.5μm wavelength range. We have used different partial pressures of several gases and also the most promising mixtures have been measured along this time in order to study its stability. For laboratory measurements we have used the spectrophotometer Cary 5 placed on the IAC (Instituto de Astrofísica de Canarias) optical laboratory. Most of the measurements have been done with a data interval of 2nm, which is enough for sampling the mixtures spectra.

4 Results

We have investigated 28 mixtures with acetylene, nitrous oxide, ammonia, hydrocarbons and chloromethans. For an accurate calibration we search for a gas mixture with a forest of lines well distributed in the spectral interval between 0.95 and 2.4μm. 7 of the 28 mixtures do not show any band or line so they have been discarded for future gas mixtures. Also in general we still have a desert of lines in the 0.9-1.5μm wavelength range. In Fig. 2 we show two promising gas mixtures of ammonia (left) and hydrocarbons (right). Mixtures with hydrocarbons, chloromethans and ammonia are pendant to be patented since they can be of interest for several projects (GIANO, PPRVS, SPIROU, CARMENES).

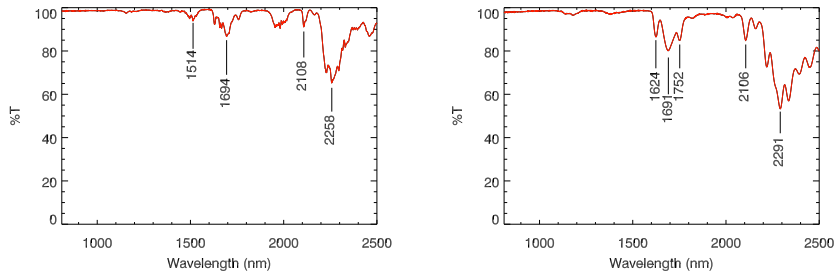

Fig. 2 Example of two promising gas mixtures. *Left*: ammonia mixture. *Right*: hydrocarbons mixture.

5 Future work

We must keep on working on new mixtures to try to cover the desert of lines that we actually find in the 0.95-1.5μm wavelength range.

We will also keep on going with the stability study with time and temperature of the most promising gas mixtures.

We plan to do high spectral resolution measurements of the best mixtures and make wavelength calibration simulations.

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References

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