Mesure du rapport isotopique $^{14}N/^{15}N$ de l'ammoniac cométaire

Measurement of the $^{14}N/^{15}N$ Isotopic Ratio in Comet's Ammonia

P. Rousselot[1], O . Pirali[2] , E. Jehin[3] , M. Vervloet[2] , D. Hutsemékers[3], J. Manfroid[3] , D. Cordier[1] , M. Martin-Drumel[2] , S. Gruet [2] , A. Decock[3], C. Arpigny[3], O. Mousis[1]

1. Institut UTINAM / OSU THETA, Besançon, France.
2. Synchrotron SOLEIL, Gif-Sur-Yvette, France
3. Université de Liège, Belgium.

Why searching for $^{15}NH_2$ emission lines in comets ?

→ Species **never detected** in comets before this work (but $^{14}NH_2$ have numerous emission lines)

→ To measure **$^{14}N/^{15}N$ isotopic ratio** in another radical / molecule than CN/HCN (→ information relative to NH_3, presumed parent of NH_2)

→ To get more constraints about the **origin of comets** because $^{14}N/^{15}N$ presents large variations in the solar system.

A difficult task...

→ $^{15}NH_2$ lines expected to be very weak (ratio of ~100 or more with respect to $^{14}NH_2$ lines)

→ The $^{15}NH_2$ lines fall in a crowded region of cometary spectra (C_2, $^{14}NH_2$).

→ Highly accurate wavelengths (~0.01 Å) needed for unambiguous detection.

→ No list of $^{15}NH_2$ lines wavelengths available in the scientific litterature.

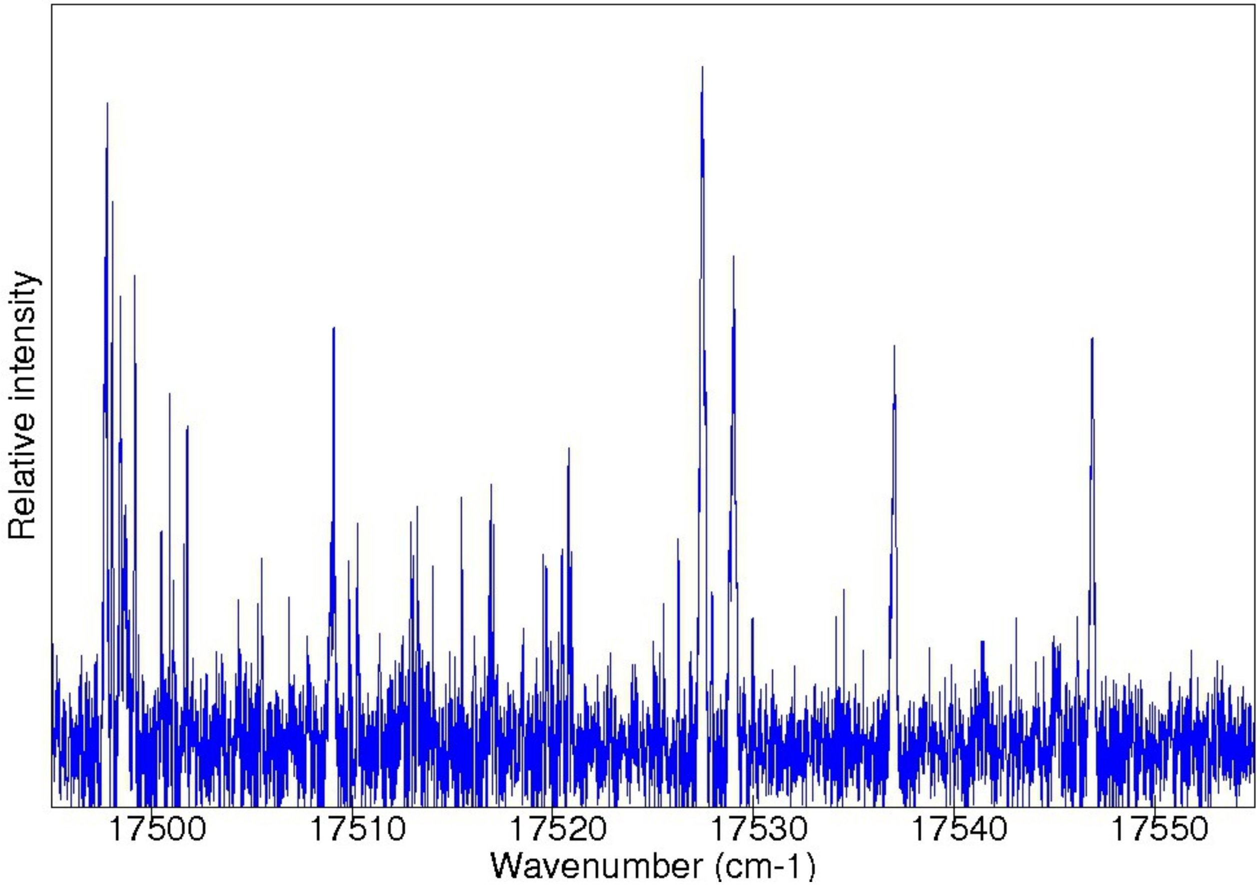
First step: laboratory experiment for measuring $^{15}NH_2$ wavelengths with accuracy

→ Laboratory experiment performed with AILES (Advanced Infrared Line Exploited for Spectroscopy) beamline of synchrotron SOLEIL near Paris.

→ Fourier Transform (FT) Spectroscopy in the range 5550-6250 Å (16000-18000 cm^{-1}) of different products obtained by the dissociation / reactions of $^{15}NH_3$ in a 13.5 MHz radiofrequency discharge: $^{15}NH_2$, $^{15}N_2$, H_2 and ^{15}NH.

→ Spectral resolution: 0.05 cm^{-1} (0.017 Å)

→ Coaddition of 288 interferograms (total acquisition time of about 2 hr)



→ **Detailed analysis of FT spectra for identifying the $^{15}NH_2$ lines mixed with $^{15}N_2$ and H_2 emission lines and measuring their wavelengths.**

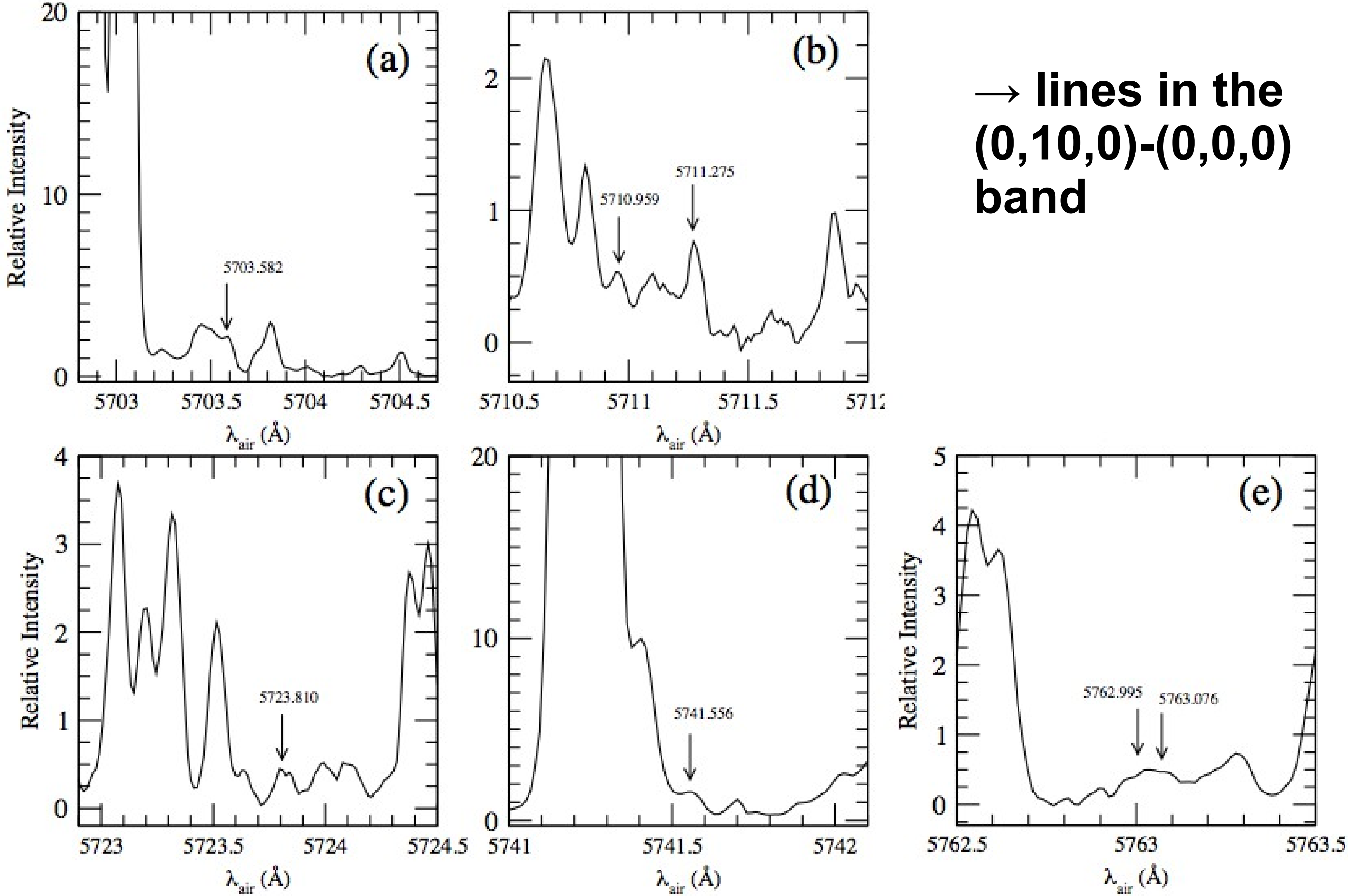
→ **(0,10,0)-(0,0,0) and (0,9,0)-(0,0,0) bands of A^2A_1-X^2B_1 transition studied.**

Second step: search for $^{15}NH_2$ lines in cometary spectra

→ **Observational data**: **39 spectra** obtained on 12 different comets between 2002 and 2011 with **UVES** at **VLT**. R≈80,000

→ **All spectra co-added** to obtain a very high S/N ratio average spectrum in spectral range studied.

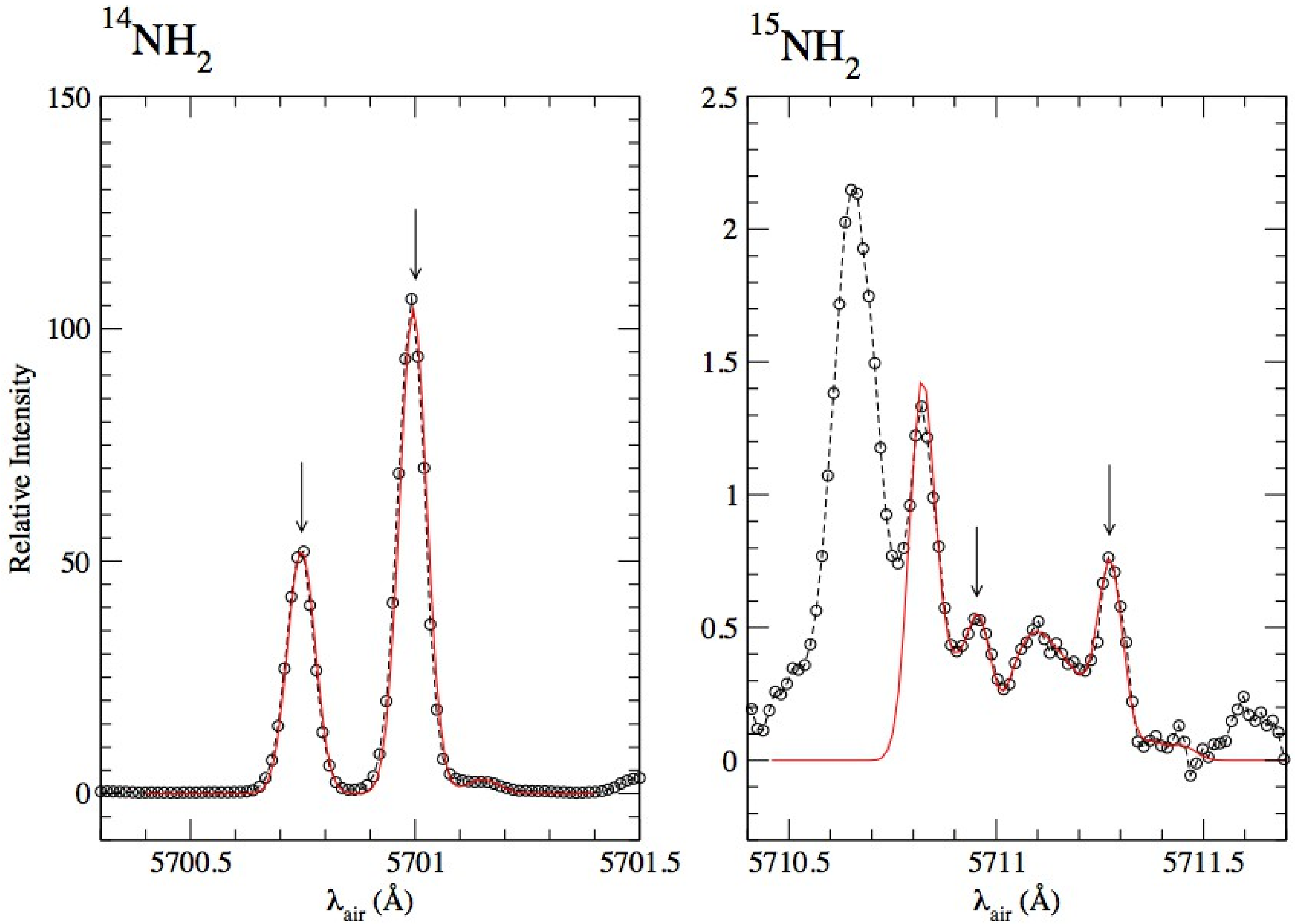
Result: positive detection of 7 $^{15}NH_2$ lines



→ **lines in the (0,10,0)-(0,0,0) band**

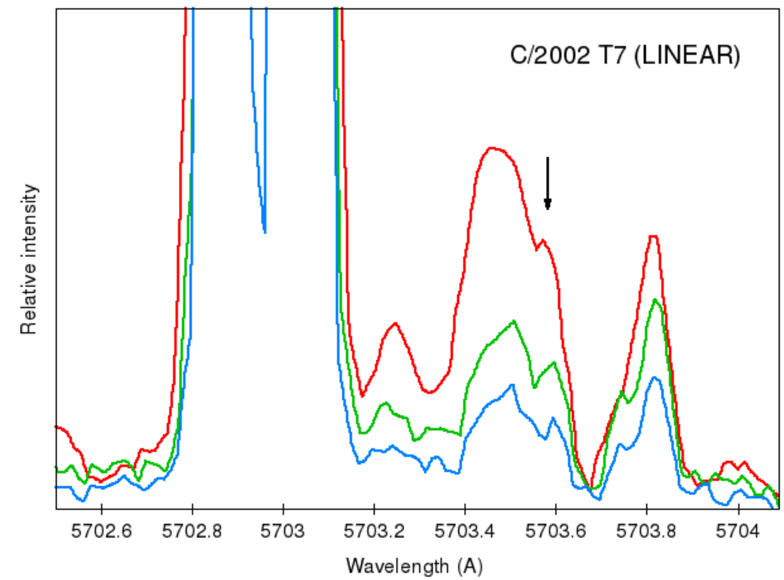
→ Average $^{14}NH_2/^{15}NH_2$ lines ratio: ~130
(in the range 80-190).

→ Probably close to $^{14}N/^{15}N$ in NH_2 and NH_3.



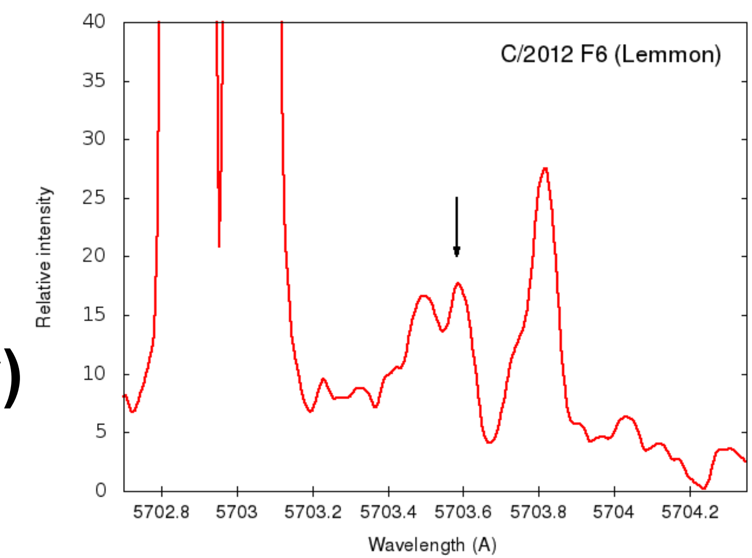
Search for variations in individual comets (work in progress)

→ **No significant variations** observed for individual comets, but **large errorbars** :



→ Ratios derived from the line at 5703.582 Å :

C/2001 V1 (NEAT): ≈ 110 (Long P.)
C/2002 Q4 (NEAT): ≈ 140 (New)
C/2002 T7 (LINEAR): ≈ 80 (New)
8P/Tuttle: ≈ 120 (Halley type)
103P/Hartley 2: ≈ 125 (Jupiter Family)



Other results (with more lines):
C/2012 F6 (Lemmon) : ≈ 140 (Long P.)
C/2012 S1 (ISON) : 139±38 (New) (Shinnaka et al. 2014)

(Short) discussion

→ Ratio $^{14}NH_2/^{15}NH_2$ ≈ $^{14}N/^{15}N$ ratio derived from CN/HCN (Manfroid et al., 2009 ; Bockelée-Morvan et al., 2008).

→ Ratio different from NH_3 in Jupiter / Solar wind (441) (Owen et al., 2001 ; Fouchet et al. 2004 ; Marty et al., 2011) and N_2 terrestrial value (272) but compatible with N_2 in Titan (143-167) (Niemann et al., 2010 ; Mandt et al., 2009)

→ Common origin for the building blocks of comets and Titan ??

→ N_2 and NH_3 result from the separation of nitrogen into at least two distinct reservoirs, with distinct ^{15}N enrichment, which never equilibrated ??

Published in Rousselot et al., 2014, ApJL 782:L16