A Fluorescence Model for $^{12}C^{13}C$ in Comets

P. Rousselot[1], E. Jehin[2], J. Manfroid[2], D. Hutsemékers[2]

[1]University of Franche-Comté, Observatoire de Besançon, Institut UTINAM – UMR CNRS 6213,
BP 1615, 25010 Besançon Cedex,France
e-mail: @obs-besancon.fr
[2]Institut d'Astrophysique, Université de Liège, Allée du six août 17,
B-4000 Liège, Belgium

The measurement of carbon isotope abundances ratio in comets permits to constrain the conditions in the outer protosolar nebula. Different measurements of the $^{12}C/^{13}C$ ratio have already been published for different solar system objects, such as the Sun, the Earth, the Moon, asteroids, planets or comets. So far all these measurements are consistent to $^{12}C/^{13}C$=90 (i.e. higher than in the ISM) but some significant differences have been seen, for example in comets [1] (from 90 to 165, depending of the authors and comets). At microscopic scales large ranges in this ratio have been found among individual small grains in the coma of comet Halley and in primitive meteorites.

Different radical or molecules have been used so far to measure this ratio in comets. They are: C_2 (visible spectroscopy), CN (visible spectroscopy) and HCN (radio spectroscopy). Despite the large intensity of C_2 Swan bands in the visible cometary spectra this radical has not been used recently to measure the $^{12}C/^{13}C$ ratio. The only papers published so far are based on medium resolution spectra and the (1,0) bandhead of $^{12}C^{13}C$ at 4145 Å [2,3,4,5]. This bandhead was chosen because it is the only one which appears distinct for $^{12}C^{12}C$ and $^{12}C^{13}C$.

Now some cometary spectra have been obtained at very high resolution and permit a new analysis of $^{12}C/^{13}C$ ratio based on $^{12}C^{12}C$ and $^{12}C^{13}C$ Swan bands that appear in the visible range. To perform this analysis we have developped a fluorescence model of $^{12}C^{13}C$. This model is based on a previous model developped for C_2 [6] but takes into account the differences of wavelengths due to the isotopic differences. Our previous fluorescence model of C_2 has also been slightly improved, thanks to new laboratory data and to a high resolution solar spectrum.

Our model takes into account six different electronic levels with all the corresponding transitions (Fig. 1). Because for C_2 all antisymmetric levels are missing, but not for $^{12}C^{13}C$ the number of levels taken into account by our model is twice for this radical than for C_2. Because pure rovibrational transition can be neglected (only electronic intercombination transitions – i.e. between singlet and triplet states – are allowed) the modeling of fluorescence spectrum is very similar to the one of C_2.

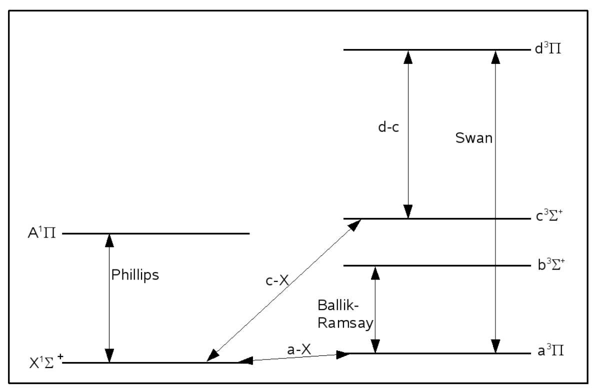

Figure 1. Energy level diagram of the $^{12}C^{13}C$ radical.

We will present our first results as well as observational data obtained with UVES, the high-resolution optical spectrograph of the ESO Very Large Telescope, which resolution is high enough to determine $^{12}C/^{13}C$ isotopic ratio.

References:
[1] Bockelée-Morvan et al. (2004) in Comets II, edts M.C. Festou, U. Keller, H.A. Weaver, 391
[2] Stawikowski and Greenstein (1964), ApJ, 140, 1280
[3] Danks et al. (1974), ApJ, 194, 745
[4] Vanysek (1991), in Comets in the Post-Halley Era, Vol. 2, ed. R. Newburn, M. Neugebauer, & J. Rahe (Dordrecht: Kluwer), 879
[5] Vanysek (1977) in Comets, Asteroids and Meteorites, ed. A. D. Delsemme (Toledo: Univ. Toledo Press), 499
[6] P. Rousselot et al. (2000) Icarus 146, 263-269.