

$^{12}\text{C}_2/^{12}\text{C}^{13}\text{C}$ isotopic ratio in comets C/2001 Q4(NEAT) and C/2002 T7 (LINEAR)

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Abstract

The measurement of the carbon isotope abundances ratio in comets allows to constrain the conditions in the outer protosolar nebula. Different measurements of the $^{12}\text{C}/^{13}\text{C}$ ratio, using various molecules, 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 with $^{12}\text{C}/^{13}\text{C} \simeq 90$ but some significant differences have been seen. In comets this ratio is remarkably constant and equal to 91.0 ± 3.6 [3] for studies based on CN radical but present larger variations with studies based on other radicals [1][5]. In this work we present a new analysis of this ratio, based on two different approaches for modeling the $^{12}\text{C}_2$ and $^{12}\text{C}^{13}\text{C}$ emission spectrum and the (1,0) and (2,1) bandheads of $^{12}\text{C}^{13}\text{C}$.

Observational data obtained at high resolution ($\simeq 70,000$) using the 8.2-m Kueyen telescope (UT2) of the Very Large Telescope (VLT) with the Ultraviolet and Visual Echelle Spectrograph (UVES) instrument have been used to test our modeling and measure the $^{12}\text{C}/^{13}\text{C}$ ratio in two different comets: C/2001 Q4(NEAT) and C/2002 T7 (LINEAR). Our modeling and numerical results will be presented.

1. Introduction

The C_2 radical is responsible for many bright emission lines in the optical part of cometary spectra, the Swan bands. These bands have been the first emission features detected in comets in 1864 by Giovanni Donati. So far very few attempts have been done for measuring $^{12}\text{C}/^{13}\text{C}$ ratio from the C_2 emission lines. This is a difficult challenge because the weak $^{12}\text{C}^{13}\text{C}$ emission lines are blended with other emission lines, mainly $^{12}\text{C}_2$ but also NH_2 . So far the (1,0) bandhead of $^{12}\text{C}^{13}\text{C}$, located at 4745 Å, was used, despite its

blending with NH_2 emission lines. In our work we have considered two different bandheads for $^{12}\text{C}^{13}\text{C}$, the (1,0) and the (2,1), located at 4723 Å in between C_2 emission lines.

2. The model

Two different approaches have been used for modeling both $^{12}\text{C}_2$ and $^{12}\text{C}^{13}\text{C}$ spectra. A first one is based on a fluorescence equilibrium spectrum (see [4] for C_2) mixed with a spectrum based on a Boltzmann distribution with a low rotational temperature (to take into account the fact that these radicals need a long time to reach their equilibrium and that they are mixed with "fresh" molecules). A second one is based on a pure Boltzmann distribution with a temperature chosen to fit the $^{12}\text{C}_2$ spectrum as well as possible.

For both $^{12}\text{C}^{13}\text{C}$ bandheads we adjust a mixture of $^{12}\text{C}_2$ and $^{13}\text{C}^{12}\text{C}$ spectra with NH_2 emission lines fitted in intensity to match the observed spectrum.

3. The data

Our model is compared to high resolution spectra obtained at the European Southern Observatory (ESO) using the 8.2-m Kueyen telescope (UT2) of the Very Large Telescope (VLT) with the Ultraviolet and Visual Echelle Spectrograph (UVES) instrument. This instrument is a cross-dispersed echelle spectrograph designed to operate with high efficiency from the atmospheric cut-off at 300 nm to the long wavelength limit of the CCD detectors (about 1100 nm). Our spectra were obtained with a resolving power $\lambda/\Delta\lambda \simeq 70,000$. After the usual data processing (flat-fielding, wavelength calibration, Doppler correction for geocentric velocity...) we have used a solar spectrum convolved with a similar instrument response function to subtract it [3]. Two different comets have been observed: C/2001 Q4 (NEAT) and C/2002 T7 (LINEAR).

4. Conclusion

$^{12}\text{C}^{13}\text{C}$ (1,0) and (2,0) bandheads are clearly detected in our spectra that cannot be properly modeled without them. Accurate fitting of the data is difficult, because of the weakness of these bandheads and probably the difficulty to completely remove the solar scattered spectrum. Our determination of the $^{12}\text{C}/^{13}\text{C}$ ratio, nevertheless, is in agreement with both bandheads and both modeling approaches. We will soon present numerical results obtained from this work for the $^{12}\text{C}/^{13}\text{C}$ ratio. These results will be compared to the one already obtained for studies based on CN radical, allowing a more detailed comparison of the $^{12}\text{C}/^{13}\text{C}$ isotopic ratio for different molecules.

References

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