EPSC Abstracts
Vol. 8, EPSC2013-925, 2013
European Planetary Science Congress 2013

Study of the forbidden oxygen lines in comets at different heliocentric and nucleocentric distances

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1. Introduction

Oxygen is an important element in the chemistry of the Solar System objects given its abundance and its presence in many molecules including H_2O, which constitutes 80% of cometary ices. The analysis of oxygen atoms in comets can provide information not only on the comets themselves but also on our Solar System. These atoms have been analyzed using the three forbidden oxygen lines [OI] observed in emission in the optical region at 5577 Å (the green line), 6300 Å and 6364 Å (the red lines) [1]. These lines are difficult to analyze because their detection requires high spectral and spatial resolutions. The oxygen analysis is interesting because it allows the determination of its parent molecules.

2 Observations

Our analysis is based on a sample of 12 comets of various origins (external, new, Jupiter family, Halley type). The observing material is made of 53 high signal-to-noise spectra obtained with the high-resolution UVES spectrograph at the ESO VLT from 2002 to 2012 [2] [3] [4]. The spectra were recorded with the same instrumental setting and reduced using the same procedure, keeping the spatial information. Final 1D spectra were extracted and flux calibrated.

3. Results

First of all, after noticing that the green line is blended with one C_2 line, we created synthetic spectra of C_2 for each observing circumstances and we subtracted the latter from the cometary spectra in order to ensure the decontamination of the 5577 Å line, especially for comets rich in C_2. Then, we measured both the intensity and the Full Width at Half Maximum (FWHM) of the three forbidden oxygen lines at different heliocentric distances. By comparing our G/R results with the Bhardwaj & Raghuram (2012) effective excitation rates [5], we found that H_2O is the main parent molecule when the comet is observed at a heliocentric distance around 1 AU. When the comet is located beyond 2.5 AU from the Sun, CO_2 also contributes to the production of oxygen. Therefore, studying forbidden oxygen lines could be a new way to estimate the abundances of CO_2 in comets, a very difficult task from the ground (cf. Fig. 1). According to the FWHM, we found that the green line is on average 1 km s^{-1} broader than the red lines, while the theory predicts that the red lines are broader. This might be due to the nature of the excitation source or to a contribution of CO_2 as the parent molecule of the 5577.339 Å line. At 4 AU, we found that the width of the green and red lines in comet C/2001 Q4 (NEAT) are the same, which could be explained if CO_2 becomes the main contributor to the three [OI] lines at high heliocentric distances [6].
Moreover, in order to estimate the effect of the quenching on our results, we studied the evolution of the oxygen lines at different nucleocentric distances. For closeby comets, we divided the extended 2D spectrum into several zones in order to analyze the oxygen lines as close as possible to the nucleus (down to $\sim$100 km from the nucleus for the closest comets like 103P/Hartley 2). For a sub-sample of comets, we also analyzed the oxygen lines in spectra obtained at large offset positions from the nucleus. This study will allow us to analyze the dependency of the oxygen lines on the nucleocentric distance.
Data are at time of writing under of analysis. However, given our preliminary results, these analyses shows that the main parent specie producing oxygen atoms seem to change from the centre of the nucleus to far away in the cometary tail.

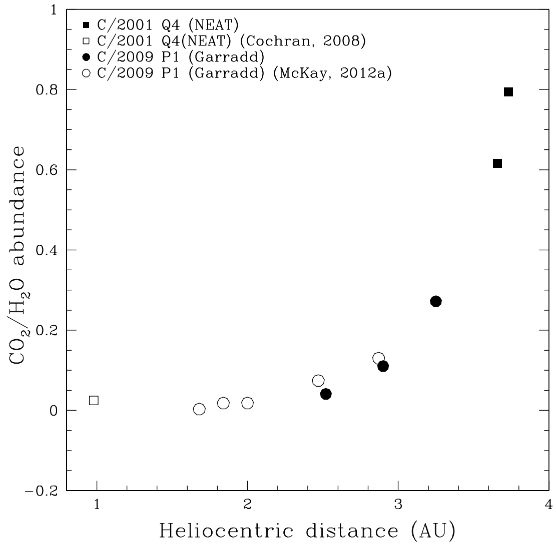

Figure 1: Evolution of the CO_2/H_2O abundance as a function of the heliocentric distance (AU). The full symbols are estimated from our G/R measurements and the empty ones are determined from G/R ratios found in the literature [7] [8]. Assuming that a higher G/R ratio comes from a more important contribution of CO_2 for large heliocentric distance comets, and measuring this ratio can give us the CO_2 abundance from ground observations.

Acknowledgements

A.D acknowledges the support of the Belgian National Science Foundation F.R.I.A., Fonds pour la formation à la Recherche dans l'Industrie et l'Agriculture. E.J. is Research Associate FNRS, P.R. is Professor, D.H. is Senior Research Associate at the FNRS and J.M. is Research Director of the FNRS.

References

[1] Swings, P.: Annales d'Astrophysique, 25, 171, 1962.

[2] Jehin. E., Manfroid. J., Hutsemékers. D., et al.: Earth, Moon and Planets, 105, 167-180, 2009.

[3] Manfroid. J., Jehin. E., Hutsemékers. D., et al.: Astron. Astrophys., 503, 613-624, 2009.

[4] Dekker, H. D'Odorico, S., Kaufer, A., Delabre, B. and Kotzlowski, H.: SPIE, 4008, 534-545, 2000.

[5] Bhardwaj, A. & Raghuram, S. 2012, ApJ, 748, 13.

[6] Decock, A., Jehin, E., Hutsemékers, D., & Manfroid, J. 2012, ArXiv e-prints.

[7] Cochran, A. L. 2008 Icarus, 198, 181.

[8] McKay, A. J., Chanover, N. J., DiSanti, M. A., et al. 2012a, LPI Contributions, 1667, 6212.