Highlights of Spanish Astrophysics VII, Proceedings of the X Scientific Meeting of the Spanish Astronomical Society held on July 9 - 13, 2012, in Valencia, Spain. J. C. Guirado, L.M. Lara, V. Quilis, and J. Gorgas (eds.)

The volatile composition of comet C/2004 Q2 (Machholz) derived from submillimeter observations

M. de Val-Borro[1,2], P. Hartogh[1], C. Jarchow[1], M. Rengel[1], G. L. Villanueva[3,4], M. Küppers[5], N. Biver[6], D. Bockelée-Morvan[6], and J. Crovisier[6]

[1] Max Planck Institute for Solar System Research, Max-Planck-Str. 2, 37191 Katlenburg-Lindau, Germany
[2] Department of Astrophysical Sciences, Princeton University, Princeton, NJ 08544, USA
[3] Solar System Exploration Division, NASA Goddard Space Flight Center, Greenbelt, MD 20771, USA
[4] Department of Physics, Catholic University of America, Washington, DC 20064, USA
[5] Rosetta Science Operations Centre, European Space Astronomy Centre, European Space Agency, PO Box 78, 28691 Villanueva de la Cañada, Madrid, Spain
[6] LESIA, Observatoire de Paris, CNRS, UPMC, Université Paris-Diderot, 5 place Jules Janssen, 92195 Meudon, France

Abstract

We have obtained production rates of several volatiles (CH_3OH, HCN, $H^{13}CN$, HNC, H_2CO, CO, and CS) in comet C/2004 Q2 (Machholz) using the Submillimeter Telescope at the Arizona Radio Observatory. We calculated the synthetic profiles using a radiative transfer code that includes collisions between neutrals and electrons, and the effects of radiative pumping of the fundamental vibrational levels by solar infrared radiation. Furthermore, multiline observations of the CH_3OH $J = 7$–6 series allow us to estimate the rotational temperature using the rotation diagram technique. We find that the CH_3OH population distribution of the levels sampled by these lines can be described by a rotational temperature of 40 ± 3 K. Derived mixing ratios relative to hydrogen cyanide are $CO/CH_3OH/H_2CO/CS/HNC/H^{13}CN/HCN$ = 30.9/24.6/4.8/0.57/0.031/0.013/1 assuming a pointing offset of $8''$ due to the uncertain ephemeris at the time of the observations and the telescope pointing error. The measured relative molecular abundances in C/2004 Q2 (Machholz) are between low- to typical values of those obtained in Oort Cloud comets, suggesting that it has visited the inner solar system previously and undergone thermal processing. The HNC/HCN abundance ratio of $\sim 3.1\%$ is comparable to that found in other comets, accounting for the dependence on the heliocentric distance, and could possibly be explained by ion-molecule chemical processes in the low-temperature atmosphere. From a tentative $H^{13}CN$ detection, the measured value of 97 ± 30 for the $H^{12}CN/H^{13}CN$ isotopologue pair is consistent with a telluric value. The outgassing variability observed in the HCN production rates over a period of two hours is consistent with the rotation of the nucleus derived using different observational techniques.

Acknowledgments

MdVB acknowledges support from the Special Priority Program 1488 of the German Science Foundation.