SUBMILLIMETER SPECTROSCOPIC OBSERVATIONS OF C/2009 P1 WITH THE JCMT TELESCOPE

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Introduction: Comets are primitive objects that harbor the most pristine Solar System materials. The composition of cometary ices, which provides the key information on the chemical and physical properties of the outer solar nebula, is often derived from observations of molecular species that sublimate directly from the nuclei. Many interesting molecules, such as HCN, CH_3OH and CO, generate bright emission lines in the submillimeter wavelength regime, and can be observed spectroscopically at high resolution yielding important information about the formation of comets [1].

The Oort Cloud comet C/2009 P1 (Garradd) reached its perihelion in late December, 2011 and this is the first time for it to visit the inner Solar System. The apparition of C/Garradd offers a great opportunity to monitor the abundances of several parent molecules over a wide range of heliocentric distances as the comet approaches the Sun.

Observations: Comet Garradd was observed in four observing runs between July 2011 and January 2012: UT 2011 Jul. 28-31, UT 2011 Sep. 23-25, UT 2011 Oct. 23-25 and UT 2012 Jan. 06-08. We used the 15 m James Clerk Maxwell Telescope (JCMT) on Mauna Kea, Hawaii. Our observations cover the heliocentric distance range from 2.49 AU to 1.56 AU.

Results: Three parent volatiles, namely HCN, CH_3OH, and CO, as well as CS – originating from the short-lived CS_2 [1] – were observed in comet Garradd before and after its perihelion. We monitored HCN J(4-3) line frequently to search for sporadic outbursts and rotational modulation. Although no short-term variability of spectral lines was observed on an hourly basis, the strength and the line shape of HCN varied with heliocentric and geocentric distances (see Figure). Rotational temperature was measured from simultaneous observations of several CH_3OH lines, following the method described in [2]. Our preliminary results show that the rotational temperature of C/Garradd varied with heliocentric distance from $T_{rot} \sim 30$ K (r = 2.49 AU) to $T_{rot} \sim 40$ K (r = 1.56 AU).

Given the mean production rate for water of 8.4×10^{28} molec s^{-1} in September 2011 [3], the preliminary abundance ratios (relative to water) of the observed molecules were: HCN (0.11%), CH_3OH (1.85%), CO (7.02%) and CS (0.07%), when comet C/2009 P1 was 1.97 AU from the Sun. Our observations show that CO in comet Garradd is somewhat enriched, which is consistent with the observations in the infrared [3]. The relative abundances of HCN, CH_3OH and CS of comet C/2009 are typical compared with other Oort Cloud comets.

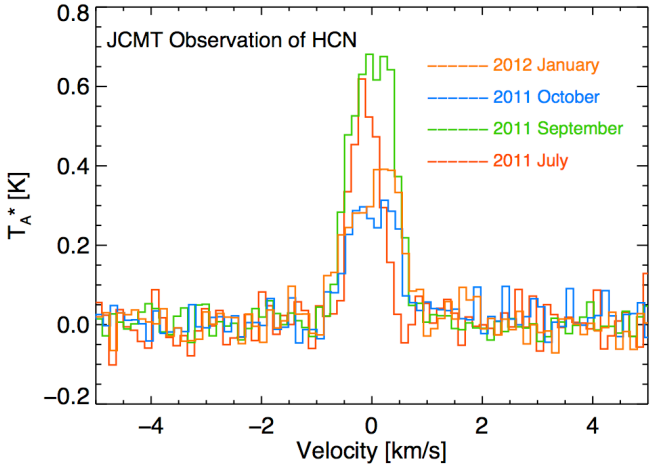

Figure: JCMT observations of HCN J(4-3) line of comet C/2009 P1. Observations made in Jul. (r=2.49 AU, Δ=1.58 AU), Sep. (r=1.97 AU, Δ=1.62 AU), Oct. (r=1.76 AU, Δ=1.95 AU) and Jan. (r=1.56 AU, Δ=1.86 AU) are shown as red, green, blue and orange, respectively. It shows that the profile and strength of the HCN line vary with respect to different heliocentric and geocentric distances.

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