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Supplementary Materials for

Ethyl alcohol and sugar in comet C/2014 Q2 (Lovejoy)

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The PDF file includes:

Supplementary Materials

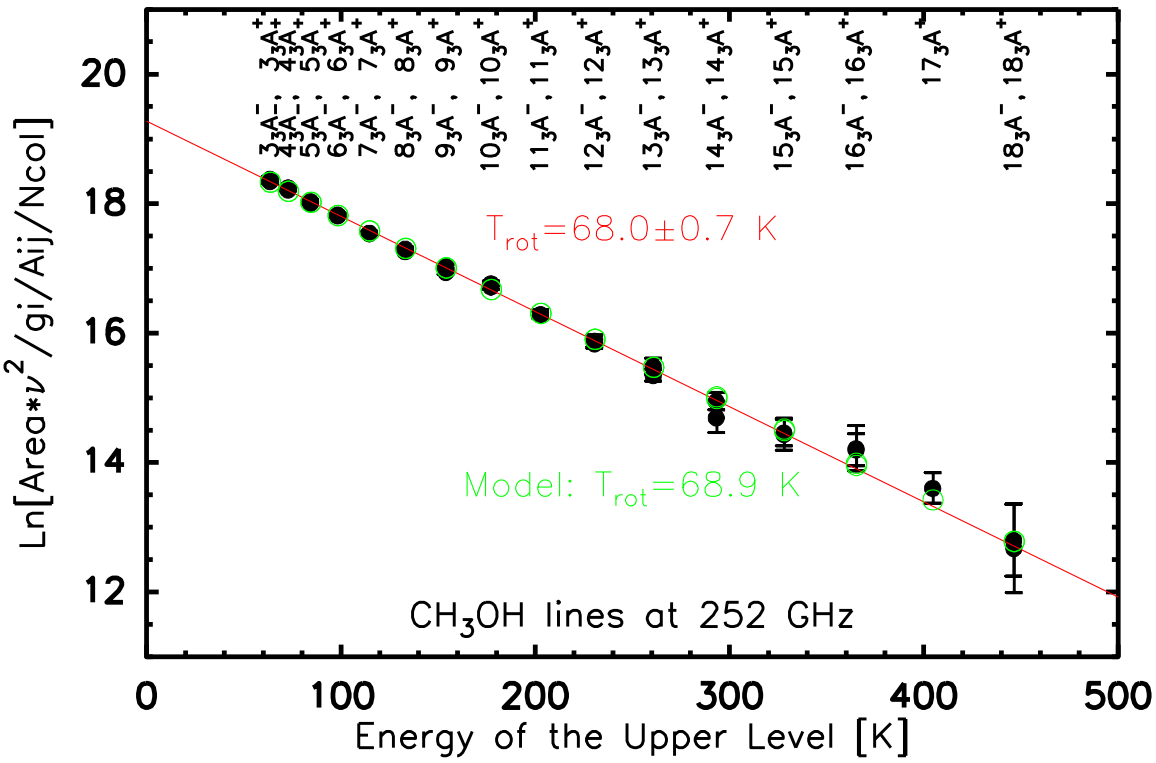

Figure S1: Rotational diagram of the methanol lines observed between 248 and 256 GHz.

These 31 rotational lines of methanol belong to the J_3-J_2 A^{+-} and A^{-+} ladders. At LTE, the logarithm of the quantity proportional to the line area (vertical scale) is expected to be linearly dependent on the energy of the upper level of each transition (horizontal scale), with the slope inversely proportional to the excitation temperature. The black dots with error-bars are the observed values and the green circles are the predictions from a model with a temperature of 73 K. The upper level of each transition is given above each point. The small departure from LTE due to radiative decay predicts a rotational temperature of 68.9 K, in close agreement with the observations: T_{rot} = 68.0 ± 0.7 K.

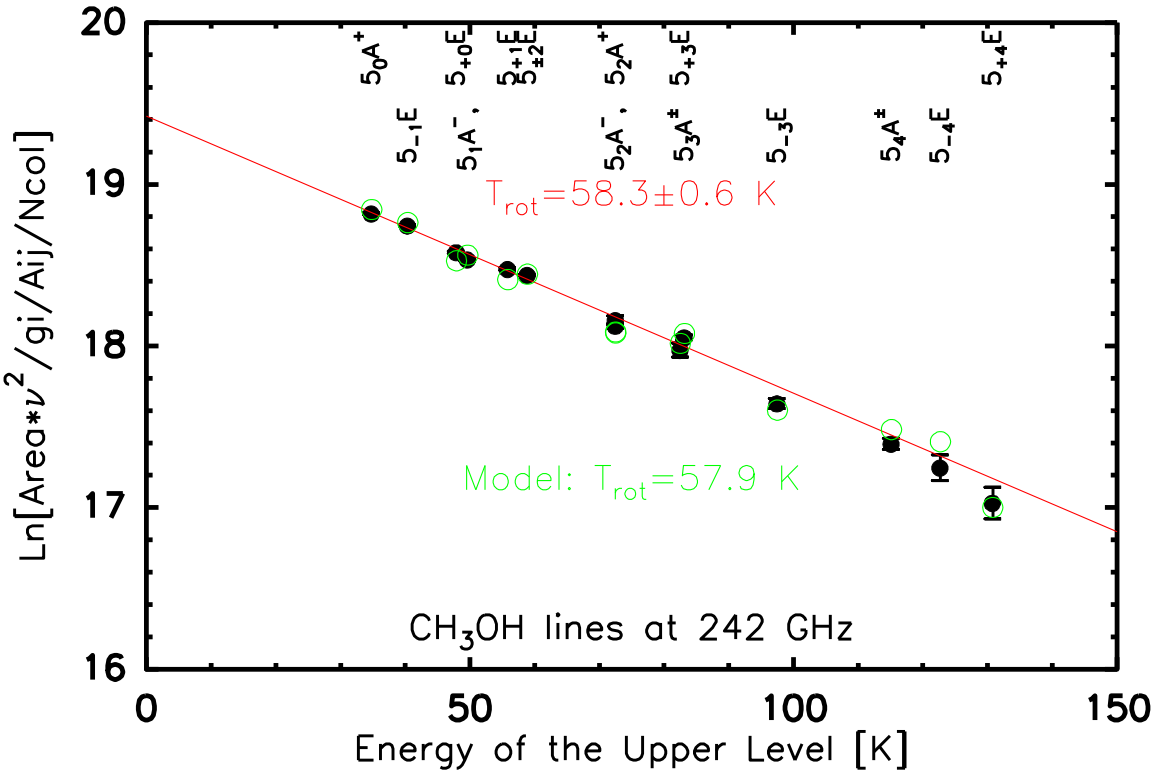

Figure S2: Rotational diagram of the methanol lines observed around 242 GHz.

These 13 rotational lines of methanol belong to the 5_K-4_K *A* and *E* ladders. Scales are as in Figure S1. The departure from LTE for this series of lines is more important than for the 251 GHz lines as the predicted rotational temperature of 57.9 K is much lower than the excitation temperature T_{gas} of 73 K. However this is in very good agreement with the observed rotational temperature T_{rot} = 58.3 ± 0.6 K and predicted line intensities (green circles).

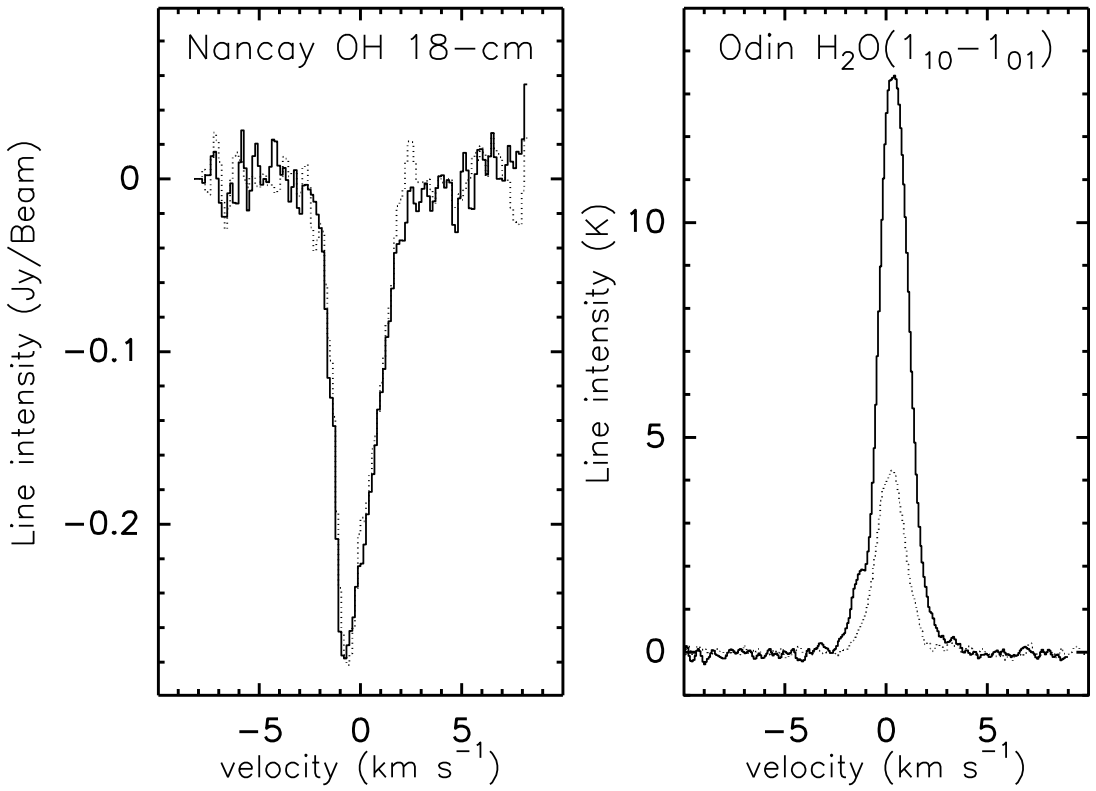

Figure S3: Water production rate: OH and $H_2{}^{16}O$ observations.

Left: Spectra of the OH maser line at 18 cm (weighted average of the 1665 and 1667 MHz lines) observed with the Nançay radio telescope on 12.8-16.8 January UT. The lines are in absorption and asymmetric due to the negative of the maser inversion (-0.23) and its derivative at the heliocentric velocity of the comet. Full line: spectrum obtained at the comet center position. Dotted line: spectrum obtained at ±3' (one beam) offsets in right ascension. Both spectra were used to constrain the quenching of the maser in the inner coma to derive accurate OH production rate as in *(34)*. Vertical scale is intensity in jansky per beam.
Right: Average spectra of the $H_2{}^{16}O(1_{10}\text{-}1_{01})$ line at 557 GHz observed with the Odin satellite between 30 January and 3 February 2015. The dotted line is the spectrum obtained at 2.1' (one beam) offset. Intensity is given in the main beam temperature scale. For both pannels the horizontal scale is Doppler velocity relative to the comet rest frame.

Table S1: Observed strongest lines and production rates

Molecule	Transition	Frequency [MHz]	Intensity [mKkms^{-1}]	Total production rate [10^{26} molec.s^{-1}]
CH_2OHCHO	$7_{7,0}$-$6_{6,1}$ + $7_{7,1}$-$6_{6,0}$	245536.236	32±6	1.0±0.2
CH_2OHCHO	$8_{7,1}$-$7_{6,2}$ + $8_{7,2}$-$7_{6,1}$	257077.180	23±8	0.7±0.2
C_2H_5OH	$13_{2,11}$-$12_{2,10}$	230672.554	25±11	12±5
gauche+	$14_{1,14}$-$13_{1,13}$	231668.733	23±11	10±5
	$14_{3,12}$-$13_{3,11}$	242870.585	21± 7	9±3
	$15_{1,15}$-$14_{1,14}$	247943.406	27± 6	10±2
	$15_{2,14}$-$14_{2,13}$	256206.340	18± 7	7±3
	$15_{3,13}$-$14_{3,12}$	260141.650	37± 8	16±4
C_2H_5OH	$13_{1,13}$-$12_{1,12}$	213760.083	20±10	10±5
gauche-	$14_{2,12}$-$13_{2,11}$	247790.316	11± 6	5±3
	$15_{1,14}$-$14_{1,13}$	261286.306	26± 8	12±4
C_2H_5OH	$8_{2,6}$-$7_{1,7}$	243556.939	31± 8	11±3
trans	$9_{2,8}$-$8_{1,7}$	214267.743	33±12	17±6
	$13_{0,13}$-$12_{1,12}$	213856.261	33±11	13±4
	$14_{0,14}$-$13_{1,13}$	230991.374	32±11	12±4
	$15_{0,15}$-$14_{1,14}$	247911.867	25± 6	8±2

Line frequencies (blends of two lines for the strongest glycolaldehyde lines) are from the JPL Molecular Spectroscopy database *(31)* and Cologne Database for Molecular Spectroscopy *(32)*.
The data are the average for the period 13--25 January 2015. Only lines with a signal-to-noise ratio ≥2 are given. The mean distance to the Sun was 1.30 AU and to the Earth ≈0.57 AU.

Table S2 - Abundances relative to water

Molecule	Abundance (%)		
	C/2014 Q2 (Lovejoy)	C/1995 O1 (Hale-Bopp)	Other Comets
HCN	0.09	0.25	0.08-0.24
CO	1.8	23	<2-33
H_2CO	0.3	1.1	0.1-1.4
CH_3OH	2.4	2.4	0.6-6
HCOOH	0.028	0.05	0.05-0.18
$(CH_2OH)_2$	0.07	0.19	0.24-0.35
HNCO	0.009	0.03	0.015-0.08
NH_2CHO	0.008	0.012	0.016-0.021
$HCOOCH_3$	0.08	0.07	<0.16
CH_3CHO	0.047	0.080	0.052
CH_2OHCHO	0.016	<0.04	<0.07
C_2H_5OH	0.12	<0.20	<0.30
CH_2CO	<0.008	<0.12	

Small departure from LTE in the comae and updated spectroscopic data have been taken into account for the complex organics for all comets. Abundances in comet C/1995 O1 (Hale-Bopp) have been revised since *(3,6,7)* and in the last column we include as well updated values for COMs in comet C/2013 R1 (Lovejoy) *(8)*.