Observations of the 18 cm OH lines of 23 comets

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Abstract

Comets provide a unique opportunity to study the early solar system. They are made of roughly 80 percent water ice and 20 percent silicate dust and other materials, and understanding their composition is critical to understanding the formation of the solar system. Ground-based observations using the 100 meter Green Bank Telescope and 305 meter Arecibo telescope allow us to map and model the gas production rates and outflow velocities of 20 comets as they near perihelion.

We provide here preliminary results regarding the gas production rates and velocities of the OH molecules in a typical comet based on data that spans 16 years and over 30 comets. Our molecule velocities range from 0.47 km/s to 3.273 km/s, while our gas production rates cover three orders of magnitude from 0.36 to 123.9 x10^{28} molecules/second.

Spectral Mapping

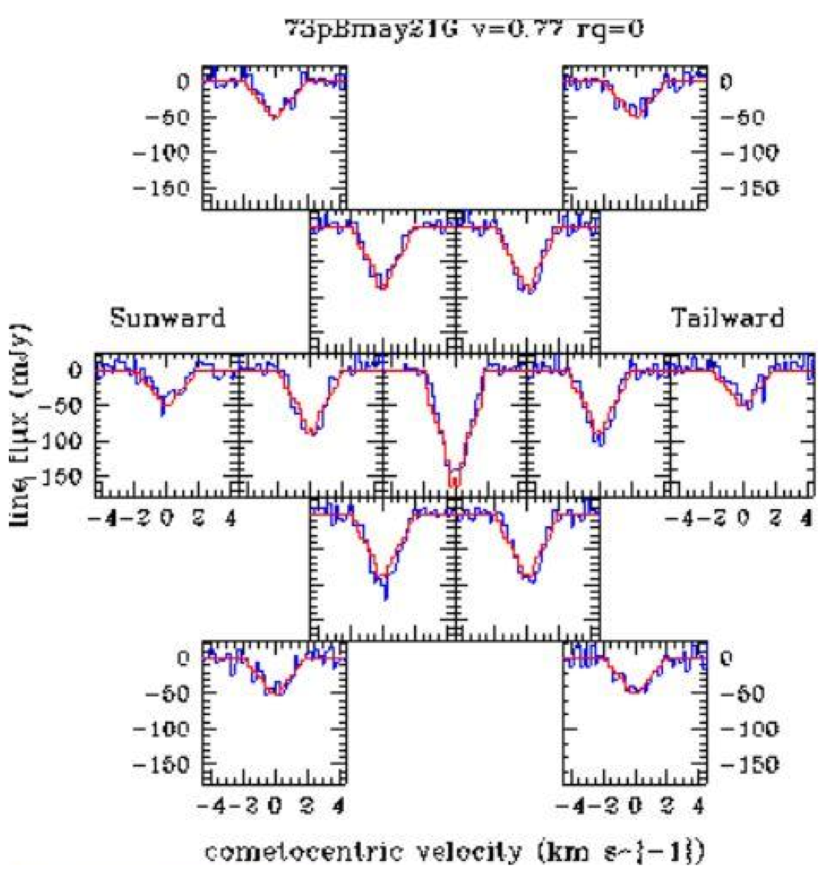


Figure 1. Example map of the comet 73P/B Schwassmann Wachmann 3 as observed on May 12, 2006 with the Green Bank Telescope.

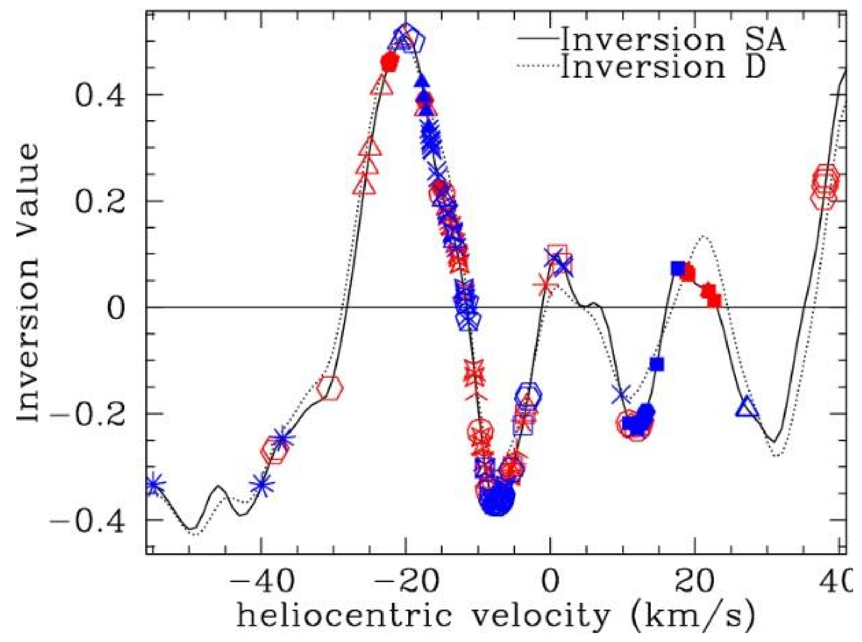
Maps of either 7 or 13 positions in a hexagonal pattern are made whenever the spectral lines are sufficiently strong. Monte Carlo simulations of the day and night side of the comet are run for a range of velocities and quenching radii.

Results

Symbol key for all figures:

C/2012 X1 LINEAR
C/2011 L4 PANSTARRS
C/2006 M4 SWAN
C/2002 T7 LINEAR
8P Tuttle
103P Hartley 2
C/2001 A2 LINEAR
C/1999 T1 LINEAR
C/2007 F1 LONEOS
C/2007 E2 Lovejoy
C/2013 R1 McNaught
C/2014 Q2 Lovejoy
C/2009 P1 Garradd
C/2003 T4 LINEAR
C/2007 N3 Lulin
9P Tempel 1
153P Ikeya-Zhang
C/2007 W1 Boattini
73P S-W 3
C/2012 S1 ISON
C/2003 K4 LINEAR
C/2004 Q2 Machholz
C/2017 O1 ASASSN

Figure 2 (Right): Inversion predictions by Schlicher & A'Hearn (SA) and Depois et al (D). Spectral lines appear as emission at positive inversions and as absorption at negative inversions. Most of the inversion curve has been sampled, except for near zero, which is intentionally avoided.



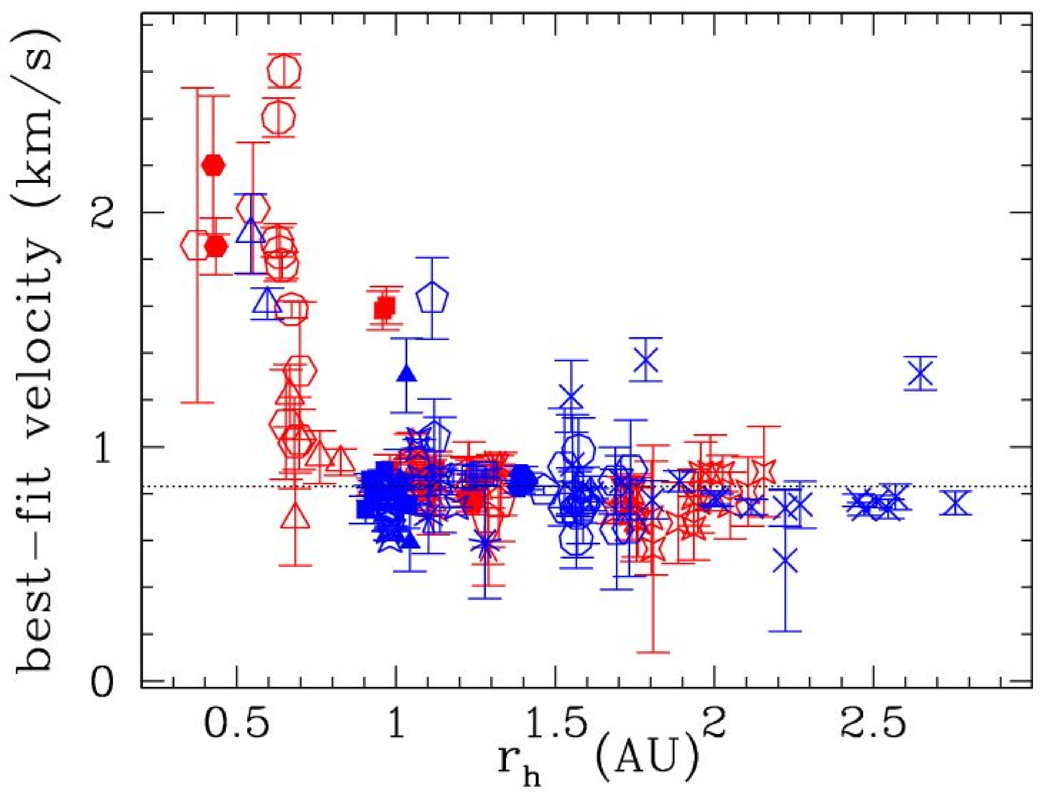


Figure 3. There is a clear correlation between the heliocentric distance and the OH daughter molecule velocity, though the velocities level off rather than continuing to decrease with increased distance from the sun.

The velocity, averaged over all comets, is 0.868 ± 0.004, whereas the average velocity just for comets outside 1 AU is 0.831 ± 0.004 km/s (dashed line).

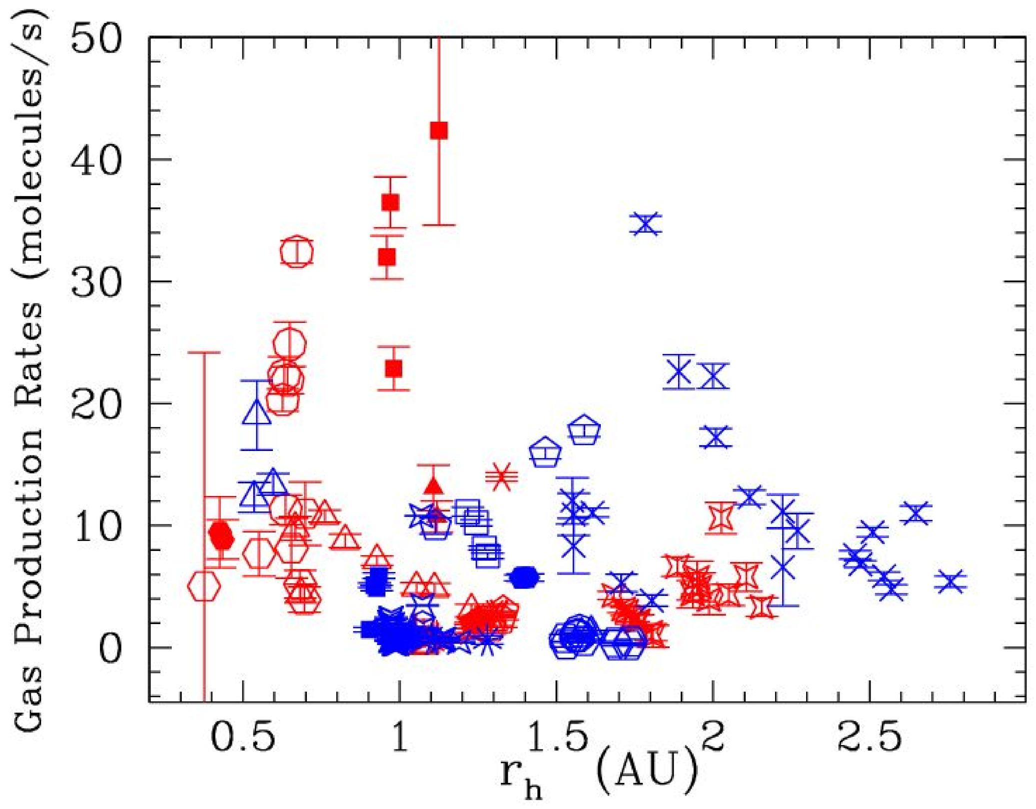


Figure 4. The heliocentric distance versus OH production rate of the comets. There does not appear to be a clear correlation between the distance and the OH production rate, though we do see highest gas productions nearer to the sun.

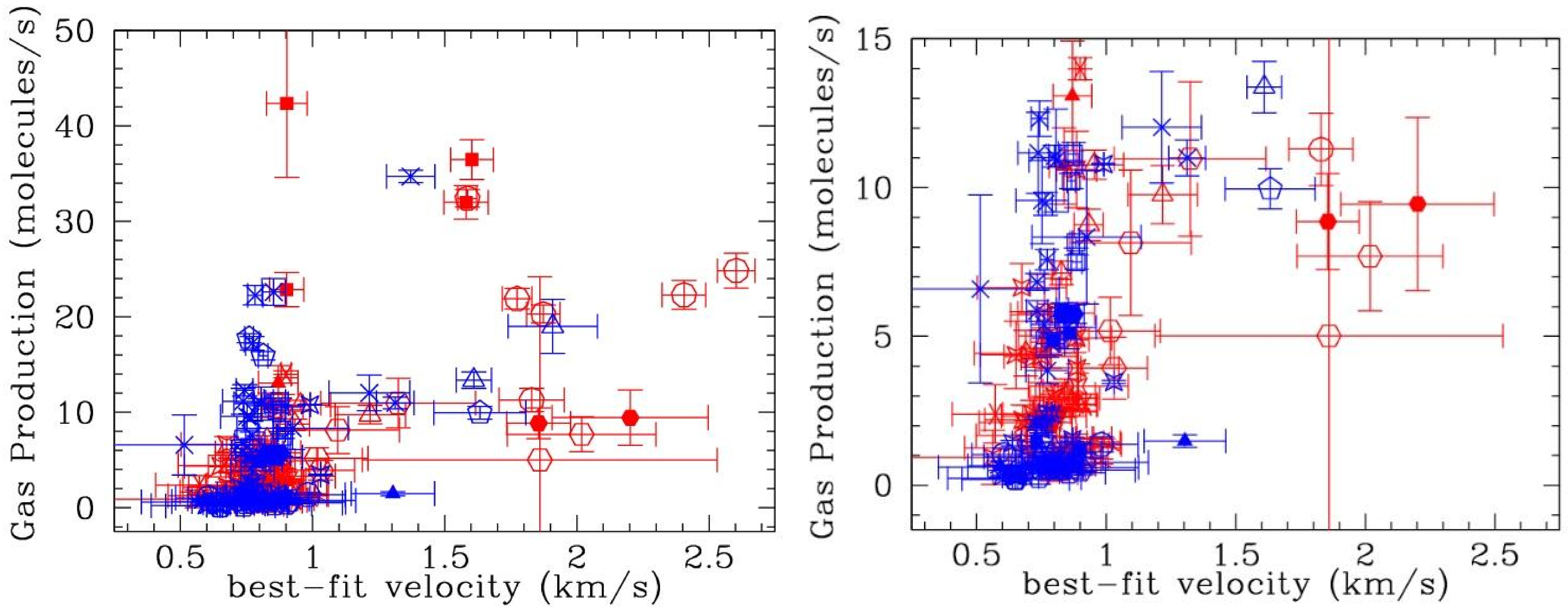


Figure 5. OH velocity versus gas production rate, for all observations on the left, and only low production comets (<1.5x10^{29} molecules/s) on the right.

Sample Spectra

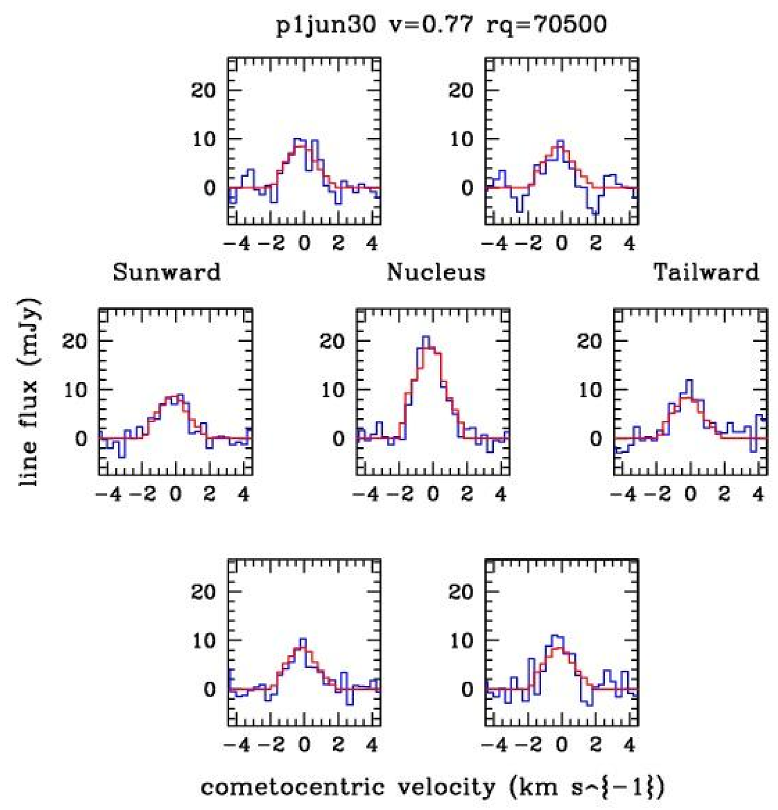
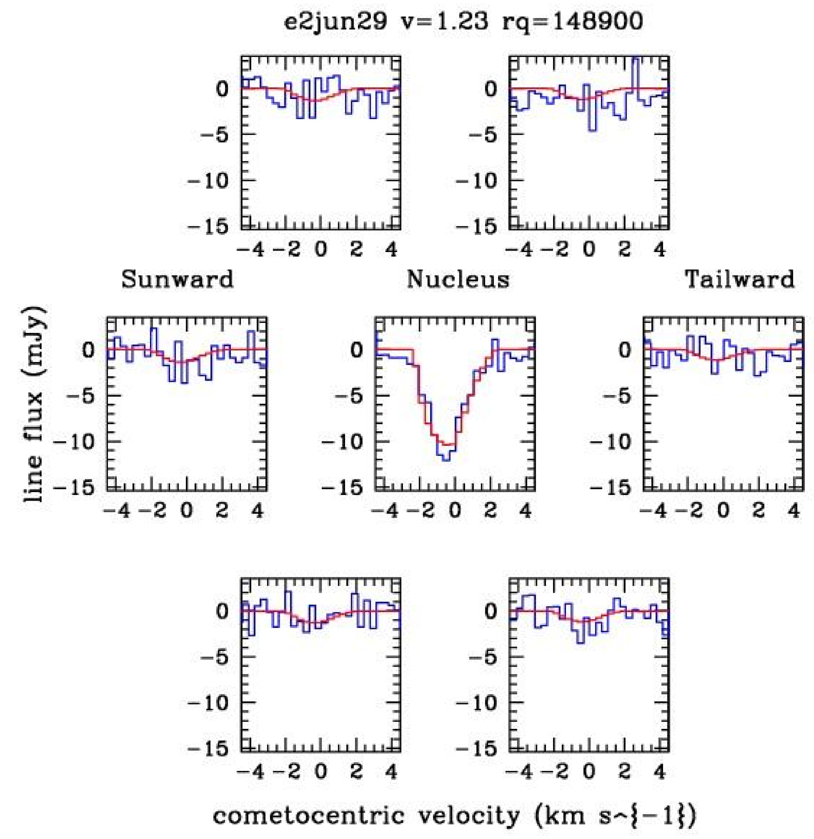


Figure 6. Example spectra for P1 Garradd (above) at 2.757 AU from the sun on June 30, 2011 and E2 Jacques (below) at 0.666 AU from the sun on June 29, 2014.



Conclusions and Future Work

Models reveal correlations between gas outflow velocity and heliocentric distance, but fewer correlations between gas production with distance or gas production with velocity.

Several comets had poor results for the best fit model, perhaps due to their very high velocities or inversion factor. We hope to narrow down places where the model does not work well. Our current models also depend on an initial OH velocity of 1.05 m/s. Future work could examine the impact on the best fit of varying that number.

References

Lovell et al (2002) *Proceedings of Asteroids, Comets, Meteors (ACM 2002), ESA-SP-500*, 681.
Despois D. et al. (1981) A&A, 99, 320-340. (Inversion D)
Schleicher D.G. & A'Hearn M.F. (1988) ApJ, 331, 1058-1077. (Inversion SA)