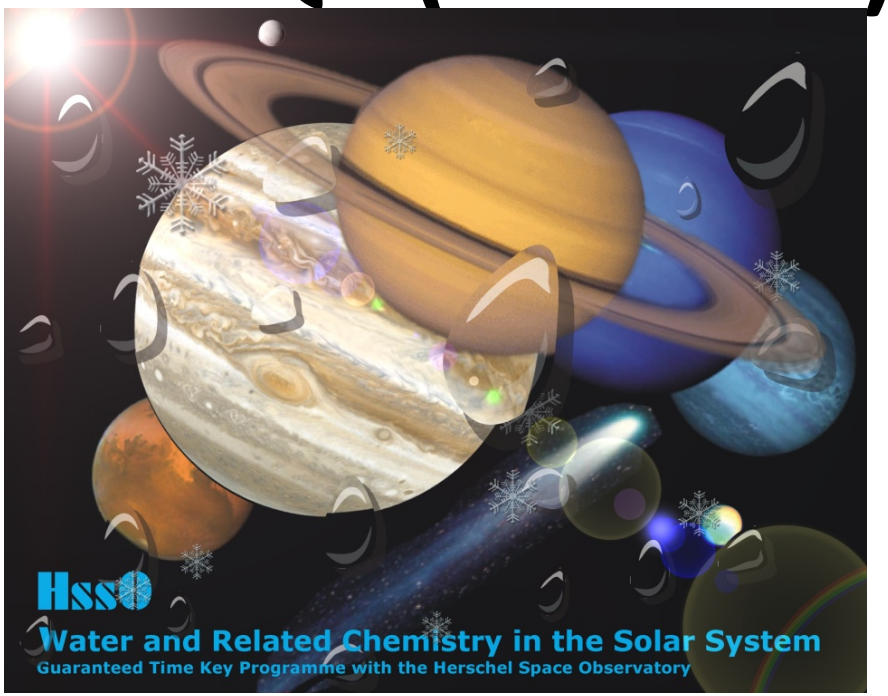
HIFI Observations of Comet C/ 2008 Q3 (Garradd)



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Outline

- Some facts on the comet
- HIFI observations
- Data analysis
- Summary

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C/2008 Q3 Garradd

- Discovered on 27 September 2008 by Gordon Garradd (Siding Spring Survey, SSS) Siding Spring Observatory (149 E, 31 S)

C/2008 Q3 (Garradd)

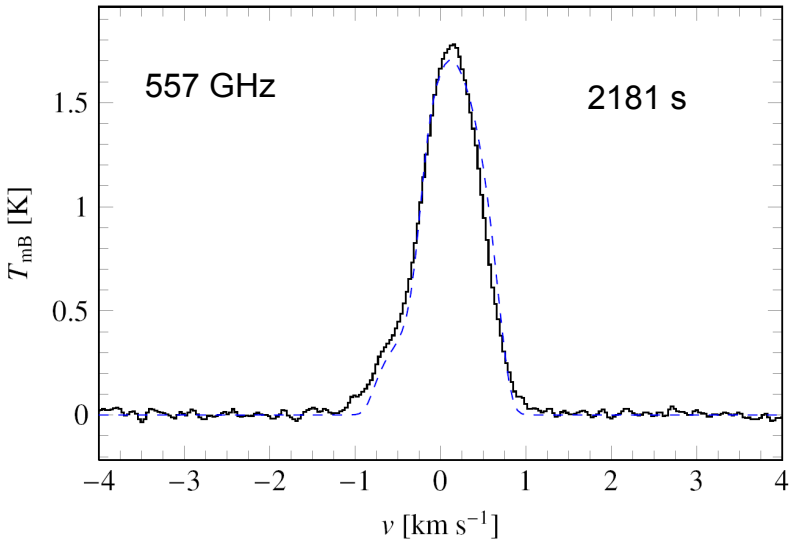
Credit: JPL
Wide-field Infrared Survey Explorer (WISE)

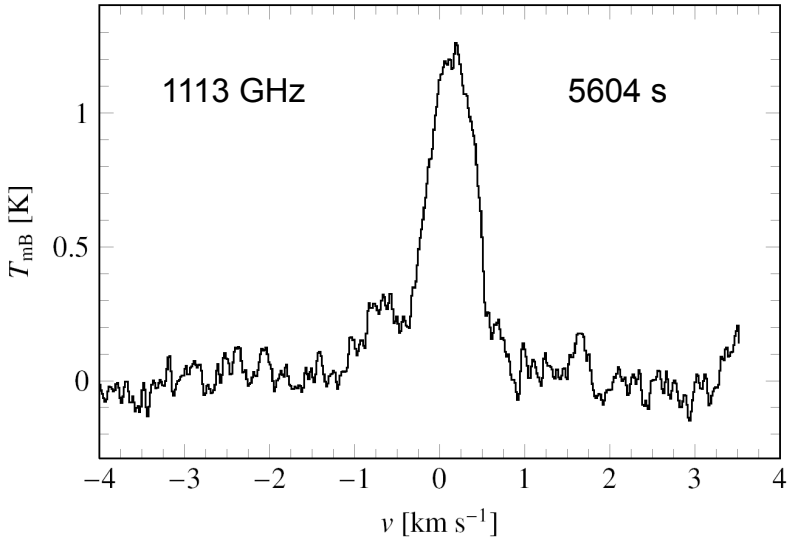
- A long-period comet (P = 190,000 yr) from the Oort cloud
- Distance : perihelion on 23 Jun. 2009 at 1.8 AU
  from Herschel
- Rather Bright (mv = ~ 7 @1.8 AU)
- Date of observations: 20 – 27 July 2010 at 1.8 AU (Sun) and 1.9 AU (Herschel)

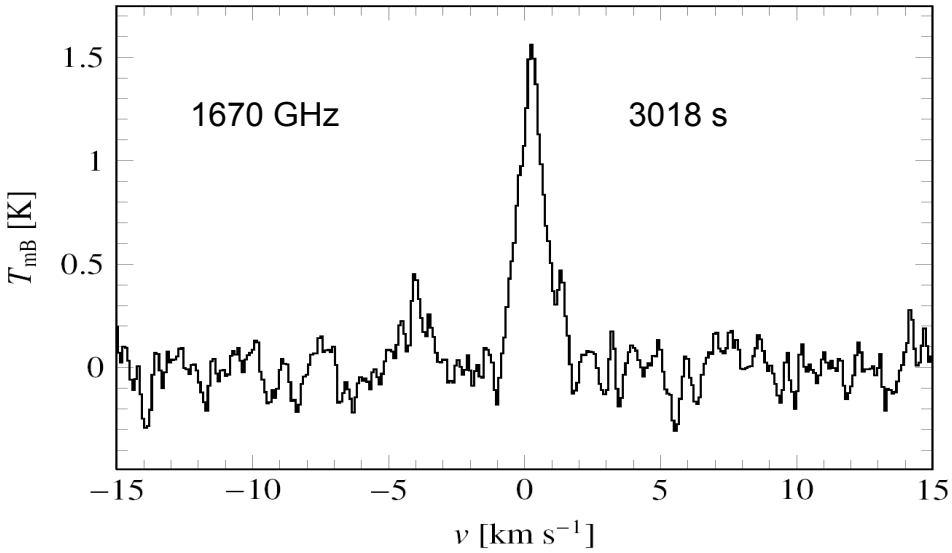
HIFI observations

- Water lines:
  - 110-101 (ortho) 556.936 GHz 38.1 ’’ (17000 km)
  - 111-000 (para) 1113.343 GHz 19.2 ’’ (34000 km)
  - 212-101 (ortho) 1669.9 GHz 12.7 ’’ (51000 km)
- First detection in a comet (lower 2 lines)
- Better constraints on excitation models
- Frequency Switch: throw = 92 MHz
- Position Switch: off pos. 0.5 deg from comet

All lines in FSw mode







Band 6: baseline removal critical issue. Seems not to be caused by standing waves only.

Coma Expansion Velocity

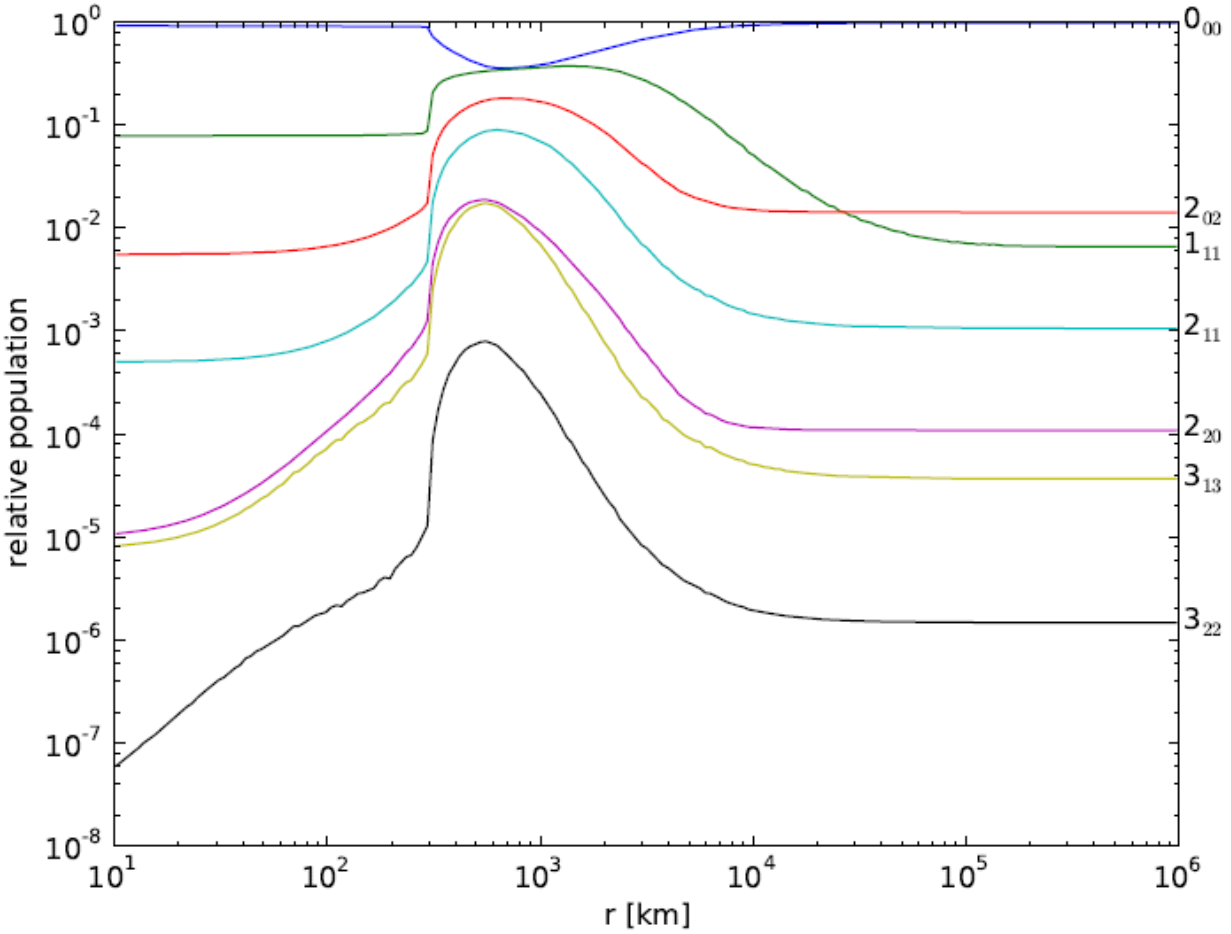
- Self absorption makes the lines asymmetric
- The redshifted side is not opaque. It is used to determine the outgassing velocity.
- It has been determined to be 550 m/s.

Line excitation mechanisms

- Water-water collisions dominate in inner coma

- Infrared fluorescence by solar radiation and water electron collisions contribute to the detected emissions from the outer coma

Level populations of para water



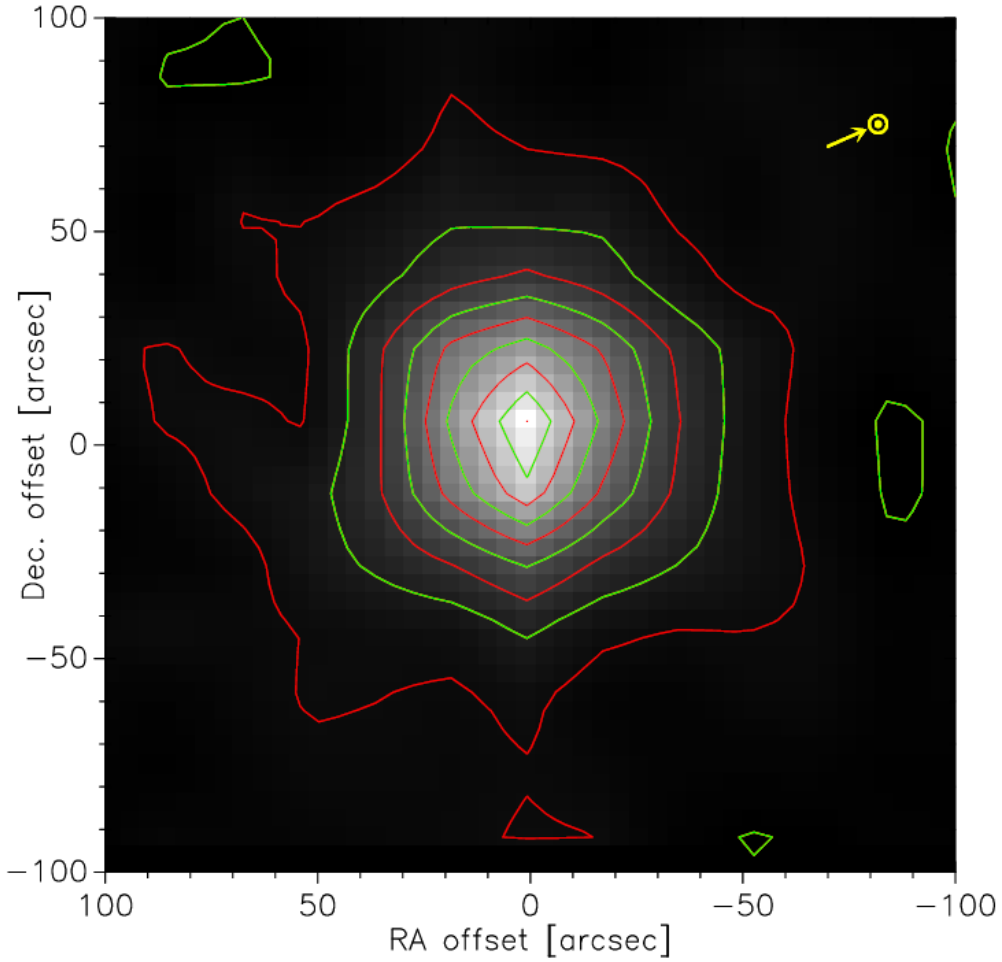
Modeling the line shape

- Two methods:
  - Accelerated Monte Carlo radioative transfer (Hogerheijde & van der Tak, 2000; Bensch & Bergin 2004)
  - Sobolev escape probability method (Bockeleé-Morvan 1987; Biver 1997).
- Results very similar (within 5 %)

Model Inputs

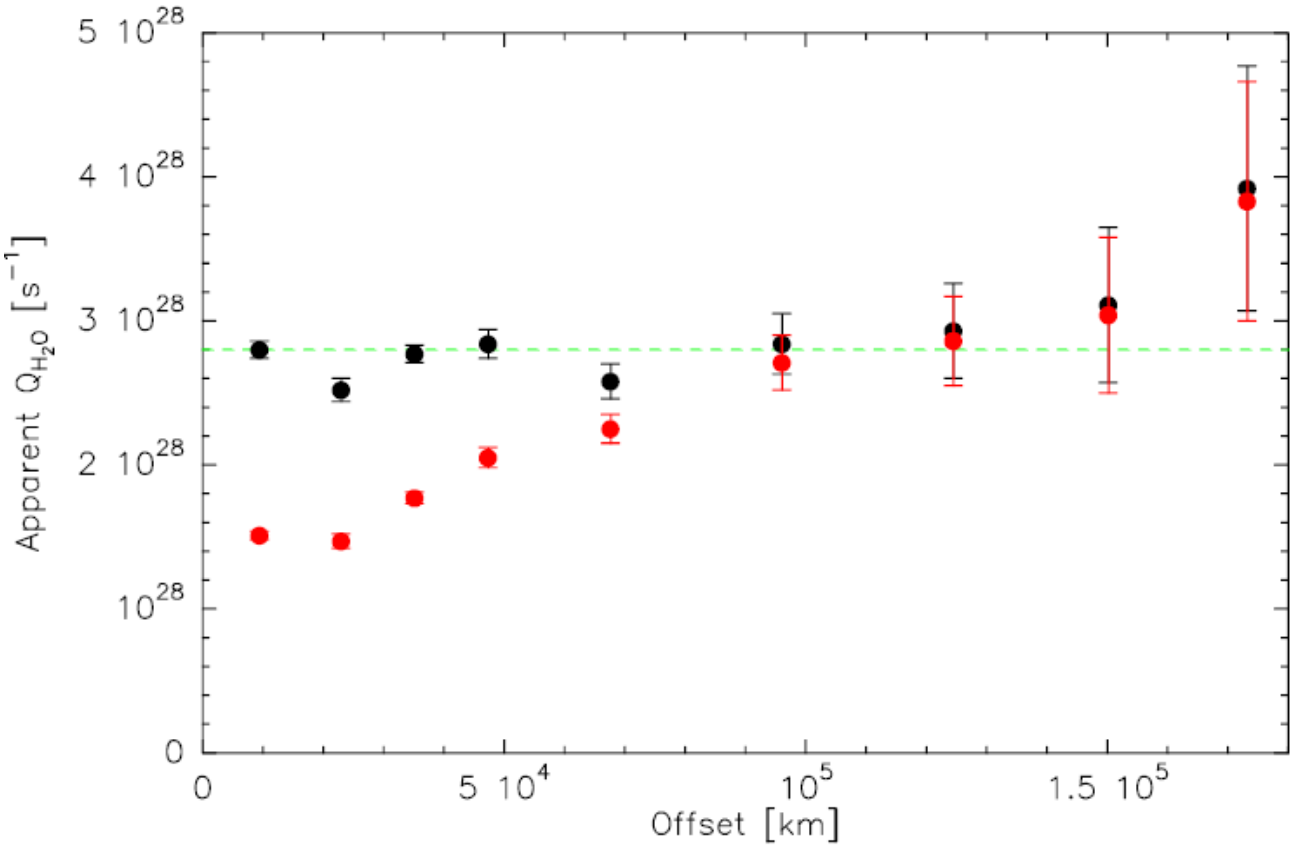
- Gas density profile: Haser model
- Expansion velocity and neutral gas kinetic temperature constant in coma
- Ortho-to-para water abundance ratio: 3 (Crovisier et al, 1998).
- Molecular data from LAMDA (Schöier et al. 2005)
- Electron densitiy profile from 1P/Halley according to Biver (1997)
- Electron density profile scaled to C/2008 Q3
- Xne is a free scaling parameter in the model, derived from radial brightness distribution (Biver, 2007)
- MC-code: water-electron collisions from Faure et al. (2004)
- IR pumping rates (solar radiation) from Zakharov et al, (2007)

OTF map of C/2008 Q3 at 557 GHz



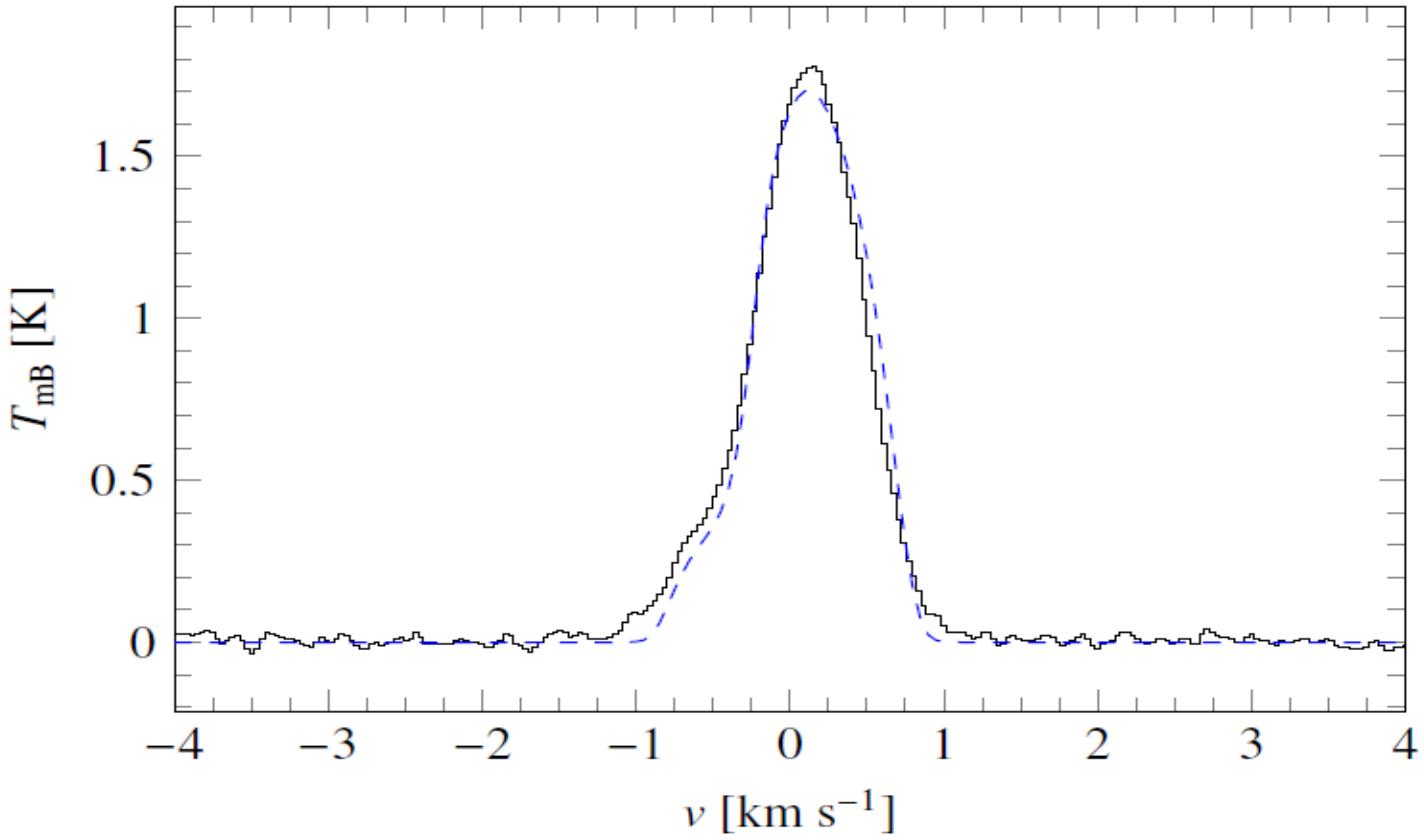
- Contours: 0.2 K km/s from 0 – 1.8 K km/s
- Map width: 300000 km
- Constrain Xne and neutral gas temperature by minimizing radial variation of water production rate at different offset positions

Water production rate for Xne = 0.2 (black) and 1



Black: Xne = 0.1 – 0.2, T=15 - 25 K

Optimal fit of observation from 20 July 2009



Expansion velocity = 550 m/s, Xne = 0.2 and T=15 K
Q[H2O] = 2.73 ± 0.01 x 10^28/s)

Production rates at 22/27 July 2009

22 July 2009 (1113 GHz) : 1.8 ±0.03 x 10^28 / s

27 July 2009 (1670 GHz) : 2.1 ±0.30 x 10^28 / s

27 July 2009 (1113 GHz) : 1.7 ±0.03 x 10^28 / s

Summary

HIFI observations of Comet C/2008 on 20-27 July 2009

First detection of the 111-000 and 212-101 rotational transitions in a comet

Derived parameters:

- Neutral gas temperature: 15 K
- Gas expansion velocity: 0.55 km/s
- Water production rates: 1.7 – 2.8 x 10^28/s

Decrease of production rates from 20 – 27 July 2009

Hartogh et al. 2010, submitted to A&A

People and institutes instrument development/ICC

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- Hartogh et al, 2009. Planetary and Space Science 57, issue 13, 1596-1606.