Deep Impact Observations with MIRO

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Samuel Gulkis
Submillimeter Observations of Tempel 1 with the MIRO Spectrometer on ROSETTA during the encounter of DEEP IMPACT

Samuel Gulkis¹, Mark Allen¹, Charles Backus¹, Gerard Beaudin², Dominique Bockelee-Morvan², Nicolas Biver², Jacques Crovisier², Didier Despois³, Pierre Encrenaz², Therese Encrenaz², Margaret Frerking¹, Mark Hofstadter¹, Paul Hartogh⁴, Wing Ip⁵, Mike Janssen¹, Lucas Kamp¹, Emmanuel Lellouch², Ingrid Mann⁶, Duane Muhleman⁷, Heike Rauer⁸, Peter Schloerb⁹, and Thomas Spilker¹

Figure provided by Biver.
Instrument Description

- 30 cm aperture telescope (7.6 arc min at 560 GHz)
- 2 uncooled, heterodyne mixers (190 GHz and 560 GHz) with phase lock loop and Ultra Stable Oscillator on 560 GHz receiver
- 2 Continuum channels
- Submillimeter (560 GHz) mixer feeds 4096 channel, high resolution (44 kHz /23 m/s) chirp transform spectrometer (CTS)
  - Fixed tuned to transitions of
    - H2O$^{16}$ (556.936 GHz)
    - H2O$^{17}$ (552.021 GHz)
    - H2O$^{18}$ (547.676)
    - CH3OH (3 TRANSITIONS) (553.146, 568.566, 579.151 GHz)
    - NH3 (572.498 GHz)
    - CO (576.268 GHz)
- Thermal line width of 560 GHz water line at 10 K is 300 kHz
- LO is frequency switched ± 5 MHz every 5 seconds and alternate spectra are subtracted to produce frequency switched spectrum
- Subject of this presentation is MIRO observations of the ground state rotational transition of water at 556.936 GHz
Ideal Frequency Switched Spectrum

FREQUENCY SWITCHED SPECTRUM

10 MHz between lobes
Tempel 1 Observations with MIRO

- Pre-Impact Observations June 29, 2005 (02 hr) to July 4, 2005 (05hr45m) [20051800200 to 20051850545]
- Post-Impact Observations July 4, 2005(06hr) to July 8, 2005 (09hr58m) [20051850600 to 20051890958]
- Observations divided into on source (Tempel 1) and off source positions.
- There is an automatic calibration every 30 minutes- movable mirror directs beam to warm calibration target, cold calibration target, and then to sky
- Spectrum is recorded every 30 seconds following the sequence of local oscillator (LO) settings [-5 MHz, +5MHz, -5MHz, +5MHz, -5MHz, + 5MHz] - each LO position is held for 5 seconds. Recorded spectrum is difference between two local oscillator settings
UNBINNED AND SMOOTHED SPECTRA
POST IMPACT (4Jul-0600/8Jul-0958)2005

-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8

3300 3400 3500 3600 3700 3800 3900 4000 4100

0.044 MHz/bin

26.4 MHz
UNBINNED AND SMOOTHED DATA WITH SUPERIMPOSED MODEL - POST IMPACT

SSB ANTENNA TEMPERATURE, K

BIN NUMBER (1 BIN = 44 kHz)
### LEAST SQUARE FIT LINE PARAMETERS

<table>
<thead>
<tr>
<th>DATA</th>
<th>LINE AMPLITUDE</th>
<th>LINE WIDTH</th>
<th>UNSWITCHED LINE POSITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>UNBINNED (IDL)</td>
<td>0.095 ± 0.021 K</td>
<td>85.2 ± 24 BINS 3.75 MHz ± 1.0 MHz 2 Km/s ± 0.54 km/s</td>
<td>Bin 3689.5 ± 16 Red shift 53.0 ± 16 bins = 2.33 MHz ± 0.7 MHz =1.25 km/s ± 0.4 km/s</td>
</tr>
<tr>
<td>SMOOTHED (EXCEL SOLVER)</td>
<td>0.11 ± 0.028 K</td>
<td>70 Bins 3.1 MHz 1.65 Km/s Deconvolved (2.50 MHz/1.34 km/s)</td>
<td>Bin 3682 Redshift 45.4 bins = 2.0 MHz =1.07 km/s</td>
</tr>
</tbody>
</table>
PRE-IMPACT OBSERVATIONS

- DATA FROM 29JUNE02HR TO 4JUL05HR45MIN 2005
  [20051800200 TO 20051850545]
- 32 BIN DATA HAS RMS OF .030 K
- NO SIGNAL WAS DETECTED
- ASSUMING A 3 SIGMA UPPER LIMIT, WE ESTIMATE AN UPPER LIMIT SIGNAL AMPLITUDE OF .090 K
- ANALYSIS IS STILL UNDERWAY
UNBINNED & SMOOTHEPRE-IMPACT DATA WITH SUPERIMPOSE 3 SIGMA UPPER LIMIT MODEL

UPPER LIMIT AMPLITUDE = 0.090 K (3 SIGMA)
NO DETAILED ANALYSIS HAVE BEEN PERFORMED AT THIS TIME

PRIOR TO THESE OBSERVATIONS, BIVER ESTIMATED (MIRO TEAM MEETING, UNPUBLISHED) THAT WATER PRODUCTION RATE OF 1E(28) MOLECULES/SEC WOULD LEAD TO A PEAK ANTENNA TEMPERATURE OF 0.125 K.

SCALING FROM BIVER’S ESTIMATE, UNBINNED LEAST SQUARE FIT OF POST-IMPACT DATAT YIELDS PRODUCTION RATE OF 7.6E(27) ± 1.6E(27) MOLEC /S

PRE-IMPACT 3 SIGMA UPPER LIMIT YIELDS MAXIMUM PRODUCTION RATE CONSISTENT WITH POST IMPACT DETECTION PRODUCTION RATE

BOCKELEE-MORVAN ESTIMATES QH2O - 6.3E(27) to 9.7E(27)(preferred value)
PRE- AND POST-IMPACT ANTENNA TEMPERATURE LIMITS
Conclusions

- The ground state rotational transition of water at 556.936 GHz was detected by the MIRO instrument in the post-impact phase of the observations. \((0.204 \text{ K km/s})\) The estimated production rate of water is \(7.6E(27) \pm 1.6E(27)\) MOLEC /S. **THIS IS A PROVISIONAL NUMBER.**

- The detection of water required long integration times. The signal to noise was too low to detect variability in the water production rate in the post-impact phase.

- No water was detected in the pre-impact phase. Assuming a 3 sigma upper limit, we cannot conclude if the water production rate changed(increased or decreased) after the DI impact.

- The MIRO results suggest a red shift gas velocity of 1.25 km/s after removing the comet - S/C doppler velocity.