

Name of research institute or organization:

**I. Physikalisches Institut, Universität zu Köln,  
Radioastronomisches Institut, Universität Bonn**

Title of project:

KOSMA - Kölner Observatorium für Submm-Astronomie

Project leader and team:

Prof. Dr. Jürgen Stutzki, observatory director

Dr. M. Miller, station manager

Universität zu Köln: M. Cubick, Dr. U. Graf, M. Hitschfeld, H. Jakob, Dr. C. Kramer,  
M. Loch, Dr. V. Ossenkopf, Dr. M. Röllig, Dr. R. Simon, K. Sun,

Universität Bonn: Prof. Dr. F. Bertoldi, Dr. U. Klein, Dr. F. Bensch, P. Müller, J.  
Pineda, Dr. S. Stanko, T. Westmeier.

Project description:

**The large scale distribution, physical and chemical conditions of the interstellar matter**

In 2006 KOSMA was in operation for 156 days (140 days observing time + 16 days for maintenance).

We could use our dual channel SIS receivers only, which is tunable in the atmospheric windows at 230 GHz and 350 GHz. The array receiver SMART was still in our institute in Cologne for upgrading.

We finished some of our large mapping projects of the last years:

The mapped area of the Perseus molecular cloud survey in  $^{13}\text{CO}$  2-1 and  $^{12}\text{CO}$  3-2 was extended to a size of  $7.10 \text{ deg}^2$ . The observations and structure analysis results are published in Sun et al. (2006).

We observed in the photon dominated regions in Cepheus B with KOSMA at  $1'$  resolution  $15' \times 15'$  fully sampled maps of [C I] at 492 GHz and  $^{12}\text{CO}$  4-3. We combined these data with FCRAO, IRAM and HIRES/IRAS data to understand the [C I] and CO emission from the PDRs in Cepheus B and to explain the observed variation of the relative abundances of both  $\text{C}^0$  and CO. The analysis with our KOSMA- $\tau$  spherical PDR model is published in Mookerjea et al. (2006).

We mapped with the 3m telescope the core ( $10' \times 14'$ ) of the Galactic star-forming region DR21/DR21 (OH) in the Cygnus X region in the two fine structure lines of atomic carbon ( $\text{C I } ^3\text{P}_1\text{-}^3\text{P}_0$  and  $^3\text{P}_2\text{-}^3\text{P}_1$ ), in four mid-J transitions of CO and  $^{13}\text{CO}$ , and in CS J=7-6. In a paper, published in A&A 461, 999 (2007), we discuss the intensities and line ratios and apply the local thermal equilibrium (LTE) and non-LTE analysis methods in order to derive physical parameters such as mass, density and temperature.

Cygnus X has been mapped in  $^{13}\text{CO}$  (2-1) ( $10.8 \text{ deg}^2$ ) at an angular resolution of  $130''$ , as well as for smaller areas in  $^{12}\text{CO}$  and  $^{13}\text{CO}$  (3-2) ( $90''$ ), using the KOSMA 3 m submm-telescope. The physical properties of the molecular gas could be derived in more detail as it was done in former studies. It is published in Schneider et al. (2006).

We observed the photon dominated regions (PRDs) in IC348 and mapped fully sampled an area of  $20' \times 20'$  in [C I] at 492 GHz,  $^{12}\text{CO}$  4-3 and 3-2 at about  $70''$

resolution. We presented the results at International Astronomical Union. Symposium no. 237 in Prague (Sun et al. 2006)

We continued our observations of the  $^{12}\text{CO}$  2-1 & 3-2 transitions in the super nova remnant HB21. This project is a in collaboration with Do-Young Byun and Bon-Chul Koo of the Korea Astronomy and Space Science Institute and Seoul National University.

In collaboration with Kaminski, T., Szczerba, R., and Tylanda, R. from Copernicus Astronomical Center, Toruń, Poland we observed on-the-fly maps covering a large area ( $\sim 3.4$  sq. deg.) around V838 Mon and did long integrations on the star position in  $^{12}\text{CO}(3-2)$  and (2-1) (Kaminski et al. 2006).

In September 2006 we had the first run of the Digital Fourier Transform Spektrometer (DFT) from ETHZ parallel with the KOSMA Acousto Optical Spectrometers (AOS). We observed  $\text{HCO}^+(4-3)$  and (3-2) in S140, W3, OriKL, NGC2264, and OriB. A second run with a modified software was in December. For more details concerning to the DFT see Benz et al. 2005.

Guest observers:

In preparation for a HERSCHEL key project several transitions were observed in S140:  $\text{HCO}^+/\text{H}^{13}\text{CO}^+(3-2)$ , (4-3),  $\text{DCO}^+(3-2)$ ,  $\text{HCN}(3-2)$ , (4-3),  $\text{CS}(5-4)$ , and  $\text{CN}(3-2)$ ,  $^{13}\text{CO}(3-2)/(2-1)$  was observed in IRAS16293, L1448, NGC1333, IRAS04368, L483 and 6 more clouds (group of Arnold Benz, ETHZ).

The group of Philipp Andre, CEA, France, had the first successful run of the CEA bolometer in March 2006.

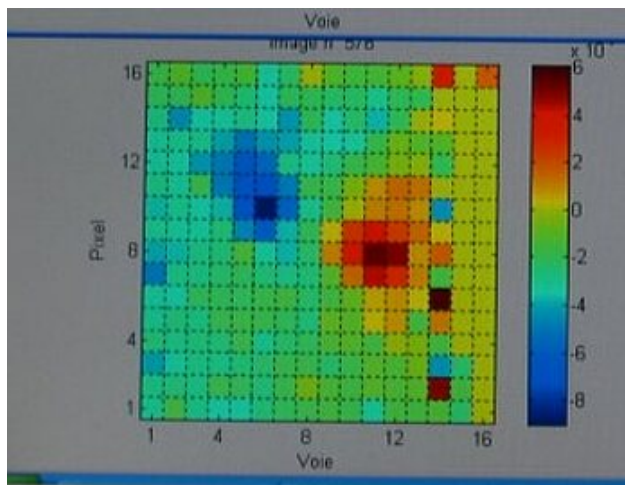


Fig. 1: Screenshot of the first Jupiter image, the blue and the red spots are the signals in the 2 wobbler positions.

The detector is a 16x16 pixels array optimized for the 450  $\mu\text{m}$  band (670 GHz). One pixel covers an area of approx.  $15'' \times 15''$  in the sky. For more details see Talvard et al. (SPIE 2006). The bolometer works well when it is cooled down to 300 mK. In the laboratory (CEA Saclay near Paris) the cooling system was normally stable for 6 hour. At Gornergrat observatory it worked well for 2-3 hours only.

We observed with the bolometer Saturn, Mars, Jupiter, Venus (no detection, because too low), Moon, and Sun. The first light (as image) was on Saturn in the evening of March 16. The image was

temperature calibrated by measuring a warm and cold absorber. We did a skydip few hours later with  $\tau(450\mu\text{m}) = 1.2$ . In the same night in the morning we observed Jupiter at an elevation 25 degree. We observed the planets in beam switch mode with a wobbling period of 2 sec. A second run of the bolometer with a more stable cooling system is planned for January 2007.

Parallel observations with our Acousto Optical Spectrometers and the Digital Fourier Transform Spectrometer (DFT)

In December we tested once more the DFT of ETHZ using a new software which can run several spectrometer servers in parallel mode. The DFT works in the frequency range up to 1GHz. One of the two DFT cards has 16768 channels with a channel spacing and resolution of 62 kHz. We compared it with measurements of our medium resolution spectrometer MRS which has 2048 channels with a spacing of 165 kHz/channel and a reception bandwidth of 600kHz. To get an equivalent DFT resolution we first binned 3 DFT channels, the new spectrum was then convolved with a gaussian resolution function with a half power width of 600 kHz. Both spectra shows the same spectral form and the same noise structure and RMS of the noise. In the future it is planned to use the DFT as backend for the KOSMA SMART receiver.

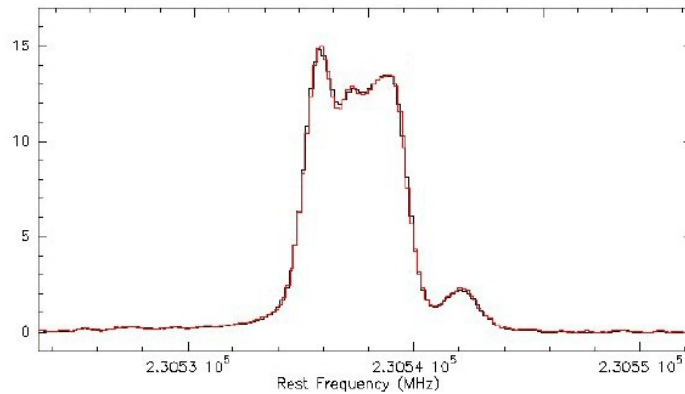


Fig. 2: Red line: MRS Spectrum of CO2-1 in OriB:  
Black line: binned and convolved DFT spectrum

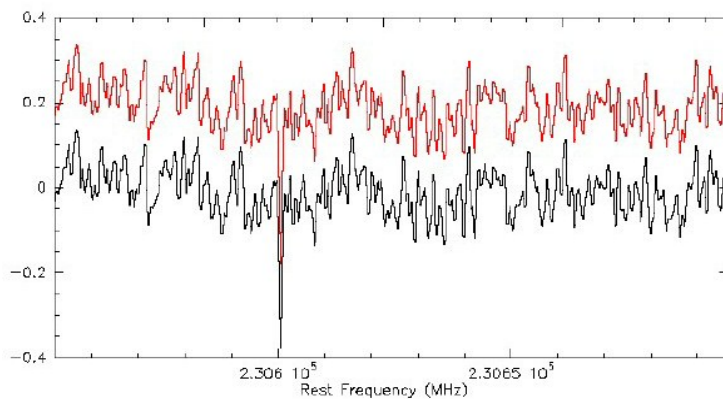


Fig. 3: Red: part of the MRS baseline, RMS = 0.050K  
Black: binned and convolved DFT baseline, RMS =

Key words:

Interstellar matter, ISM, PDR, millimeter, submillimeter wave telescope, SIS receiver, array receiver, bolometer, digital fourier transform spectrometer

Internet data bases:

<http://www.ph1.uni-koeln.de/gg>  
<http://www.astro.uni-bonn.de/~webrai/index.php>

Collaborating partners/networks:

MPI für Radioastronomie Bonn, Institut für angewandte Physik, Universität Bern, ETH Zürich, Center of Astrophysics, Boston, USA, Observatoire de Bordeaux, Astronomy Department Peking University, China, Copernicus Astronomical Center, Toruń, Poland, Korea Astronomy and Space Science Institute and Seoul National University, Service d'Astrophysique/DAPNIA/DSM CEA Saclay, Gif-sur-Yvette, France

Scientific publications and public outreach 2006:

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**Refereed journal articles**

Sun, K., Kramer, C., Ossenkopf, V., Bensch, F., Stutzki, J., Miller, M., A KOSMA 7 deg<sup>2</sup> <sup>13</sup>CO 2-1 and <sup>12</sup>CO 3-2 survey of the Perseus cloud. I. Structure analysis, *A&A* **451**, 539-549, 2006.

Mookerjea, B., Kramer, C., Röllig, M., Masur, M., Study of photon dominated regions in Cepheus B, *A&A* **456**, 235-244, 2006.

Jakob, H., Kramer, C., Simon, R., Schneider, N., Ossenkopf, V., Bontemps, S., Graf, U. U., Stutzki, J., The cooling of atomic and molecular gas in DR21, *A&A* **461**, 999-1012, 2007.

Schneider, N., Bontemps, S., Simon, R., Jakob, H., Motte, F., Miller, M., Kramer, C., Stutzki, J., A new view of the Cygnus X region. KOSMA <sup>13</sup>CO 2 to 1, 3 to 2, and <sup>12</sup>CO 3 to 2 imaging, *A&A* **458**, 855-871, 2006.

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Benz, A. O., Grigis, P. C., Hungerbühler, V., Meyer, H., Monstein, C., Stuber, B., Zardet, D., A broadband FFT spectrometer for radio and millimeter astronomy, *A&A* **442**, 767-773, 2005.

**Conference papers**

Sun, K., Kramer, C., Mookerjea, B., Röllig, M., Ossenkopf, V., Stutzki, J., Study of Photon Dominated Regions in IC348, Triggered Star Formation in a Turbulent ISM, International Astronomical Union. Symposium no. 237, held 14-18 August, 2006 in Prague, Czech Republic, **216**, S237 2006.

Kaminski, T., Miller, M., Szczerba, R., Tylenda, R., Observations of V838 Mon and the nearby region in the CO J = 1-0, 2-1 and 3-2 transitions, to appear in ASP Conf. Ser., The Nature of V838 Mon and its Light Echo, ed. R.L.M. Corradi and U. Munari.

Minier, V., Durand, G. A., Lagage, P. O., Astronomy in Antarctica, 26th meeting of the IAU, Special Session 7, 22-23 August, 2006 in Prague, Czech Republic, SPS7, **15**

Talvard, M., André, P., Rodriguez, L., Minier, V., Benoit, A., Leriche, B., Pajot, F., Vigroux, L., Agnès, P., Boulade, O., ArTeMiS: filled bolometer arrays for next generation submm telescopes, Millimeter and Submillimeter Detectors and Instrumentation for Astronomy III. Edited by Zmuidzinas, Jonas; Holland, Wayne S.; Withington, Stafford; Duncan, William D.. Proceedings of the SPIE **6275**, 2006

**Thesis**

Mathias Loch, Structure of molecular clouds in the Cygnus-X region, diploma thesis.

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