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, project leader
Dr. M. Miller, station manager
Universität zu Köln: M. Brüll, H. Jakob, Dr. U.Graf, PD Dr. C. Kramer, Dr. B. Mookerjea, PD Dr. V. Ossenkopf, Dr. M. Röllig.
Universität Bonn: Prof. Dr. U. Mebold, PD Dr. A. Heithausen, C. Böttner, Dr. C. Brüns, P. Müller, J. Pineda, Dr. S. Stanko, T. Westmeier.

Project description:

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

The central topic is the spectrally resolved observation of the global distribution of the interstellar matter in the Milky Way and nearby external galaxies, using the important mm-, submm-lines of CO (and its isotopomers), and atomic carbon ([CI] 492 and 809 GHz. These observations have been carried out with the KOSMA 3m-telescope. Two SIS receivers were used, a dual channel receiver operating at 230 GHz and 350 GHz, and the dual frequency array receiver SMART which allowed a series of successful observations of both [CI]-lines simultaneously and the transitions CO(4-3), (7-6), and ^{13}CO(8-7) .

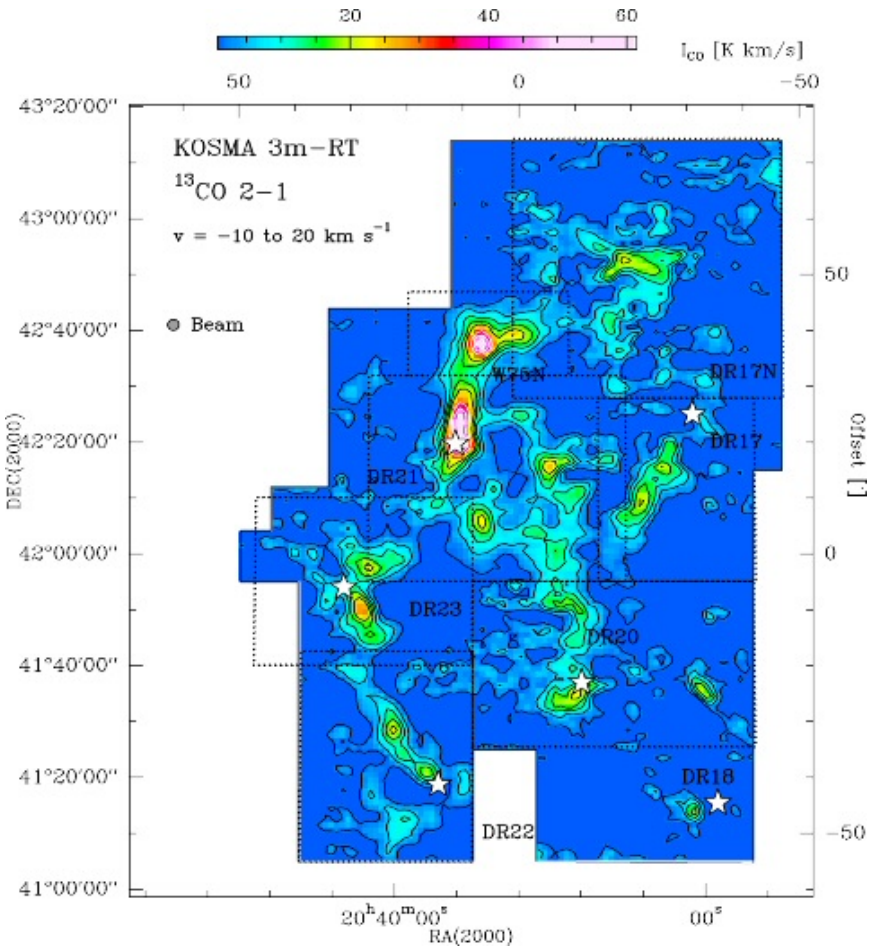
Observation in $^{12/13}$CO(3-2) and $^{12/13}$CO(2-1) were done in in Tycho supernova remnant (SNR), 3C434 SNR, many IRAS galactic point sources (search for outflows), L1457, LVC81, IVC210, MBM32, in the Cygnus rift region, in the galactic ring (this project has been finished now), Cepeus/Cepheus-B, in the Perseus region, UCHII and HII sources, S138,S149, S186, S127, and V838. C[I] 1-0, 2-1 was observed in DR21, W75, Rosetta, Cepheus-B, K3-50, ON-1, and ON-3, CO4-3 in W75, DR21, Rosette, and CephB. A small map around the center positon of DR21 was done in the ^{13}CO7-6 transition and some observations in CepB, W51, IRDC1, and Rosette. We testet the first time a Hot Electron Bolometer (HEB) as a mixer. The C[I] 2-1 and CO7-6 line could be seen in DR21 with this new device.

Long-term observations at KOSMA:

Institute	Project name	Status
1. Physikal. Institut, Universität zu Köln	KOSMA survey of molecular clouds in the Galactic Ring	finished
1. Physikal. Institut, Universität zu Köln	Nearby large molecular clouds with low mass star formation: Perseus and Serpens	^{12}CO3-2, ^{13}CO(2-1) Observations in Perseus and Serpens have been started.
1. Physikal. Institut, Universität zu Köln, Observatoire Bordeaux	The brightest Galactic OB-Cluster and its molecular environment Cygnus-X	7.5 square degrees have been .finished. Observations in ^{13}CO3-2, 2-1 and ^{12}CO3-2
1. Physikal. Institut, Universität zu Köln	The galactic star forming regions: DR21, ON1, W3, S106, Orion-A	Observations in $^{12/13}$CO 2-1 3-2, ^{13}CO 8-7 map finished CO 4-3, 7-6, and C[I] 1-0, 2-1
1. Physikal. Institut, Universität zu Köln	KOSMA mapping of the Cepheus OB3 molecular cloud	Started in Nov. 04, observations in ^{13}CO2-1 and ^{12}CO3-2
Institut für Radioastronomie, Universität Bonn	Interplay between turbulence and gravity in dense cirrus cloud cores	finished
Institut für Radioastronomie, Universität Bonn	Search for molecular gas in intermediate velocity clouds (IVC) and high velocity clouds (HVC)	finished
Observatoire Bordeaux, 1. Physikal. Institut, Universität zu Köln	Rosette	^{13}CO 8-7
University Seoul, Korea	Supernova remnants	3C434 and Tycho in ^{12}CO2-1, 3-2
Astronomy Department, Peking University	Outflows in IRAS point sources	$^{12/13}$CO2-1, 3-2, finished
Beijing Astronomical Observatory (BAO)	Ultra compact HII regions	$^{12/13}$CO 2-1, 3-2, finished

In the following, we will briefly present two of our projects to highlight the science being done at the KOSMA telescope.

Nearby large molecular clouds with low-mass star formation



This project is in order to have an unbiased study of nearby (within 350pc) large molecular clouds, such as Perseus, Serpens, Ophiuchus and so on with the KOSMA 3m submillimeter telescope at arcminute resolutions which is the advantage of this telescope to understand the physical and chemical conditions under different levels of star forming conditions.

We have finished the observations in Perseus with ^{12}CO 3-2 and ^{13}CO 2-1 in the last observational season (2004), which covers about 7.10 square degrees and is the second largest region observed by KOSMA so far. The Perseus molecular cloud is one of the best examples of the nearby low- and intermediate-mass star forming regions. There are an active star forming region (NGC1333), a young open cluster (IC348) and a dozen dense cloud cores with low levels of star forming activities (L1448, L1455, B[arnard] 1, B1 EAST, B3 and B5). And for the cold core B1, a magnetic field has been measured using OH Zeeman effect. The cloud exhibits a wealth of substructures such as cores, shells and filaments and dynamical structures (outflows, jets and a large-scale velocity gradient).

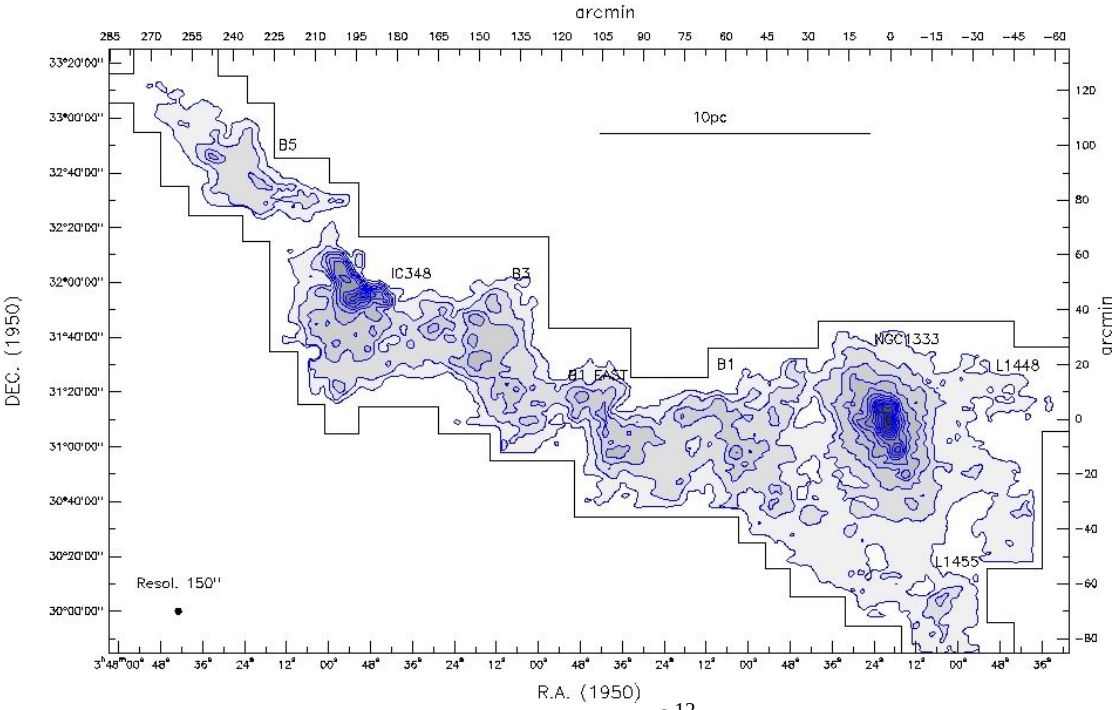


Fig. 1. The integrated intensity map of ^{12}CO 3-2 in Perseus.

The internal structure of the interstellar medium (ISM) is possibly random to a large degree. The structural properties of a random function are included within its power spectrum. Its power-law behavior suggests a hierarchical structure organization, which is due to the turbulent internal cloud motion. So it is very important to study the power-law spectra from the observed images. We have analyzed the data with the Delta-variance to detect to power-law spectra indices. We found that the index of 12CO 3-2 and 13CO 2-1 is nearly same for the whole intensity maps, but it significantly varies in different sub-regions for the both transitions, with the trend that more active star forming regions show a steeper index. For the individual channel maps we find steeper indices for line core channels and a gradually decreasing index for the channel maps as a function of velocity difference to the line center. The index nearly keeps the same with the increase of velocity width in most of the sub-regions and we obtained an average index of about 2.9 for different velocity width in those sub-regions

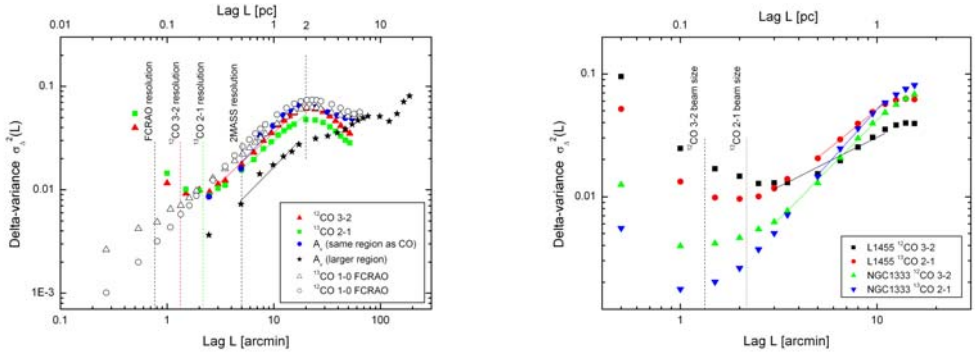


Fig. 2 Results of Delta-variance for the whole intensity maps and individual sub-regions.

The richest Galactic OB cluster and its molecular environment: Cygnus X
Giant Molecular Clouds are objects of extreme contrasts ranging from dense, cold filaments and clumps to hot, tenuous regions, cleared out by clusters of newly born OB stars. The formation of (high mass) stars takes place in massive, warm molecular cloud cores. In order to refine the theory of massive star formation and to investigate possible external triggering, we started a large scale study of the physical and dynamical properties of the very active molecular cloud complex Cygnus X, one of the main goals being to obtain a complete census of the high mass star forming dense cores.
Between 2001 and 2005, we imaged the distribution of lower density gas over 7.5 deg^2 in Cygnus X in the 13CO 2-1 line and the most active regions in the observationally more demanding ^{13}CO 3-2 line and in ^{12}CO 3-2 using the KOSMA 3m submm telescope. The region was also surveyed with the FCRAO telescope in ^{13}CO, $C^{18}O$, N_2H^+ 1-0, and CS 2-1 (5 deg^2, ongoing since 2003). The ^{13}CO data reveal two regions with very different properties: the highly filamentary and active DR21/W75N region (east of OB2) and the more diffuse, quiescent IC1318 b/c ridge to the south. They reflect different stages of star formation, with the more active regions being more evolved and star formation triggered by the cluster.

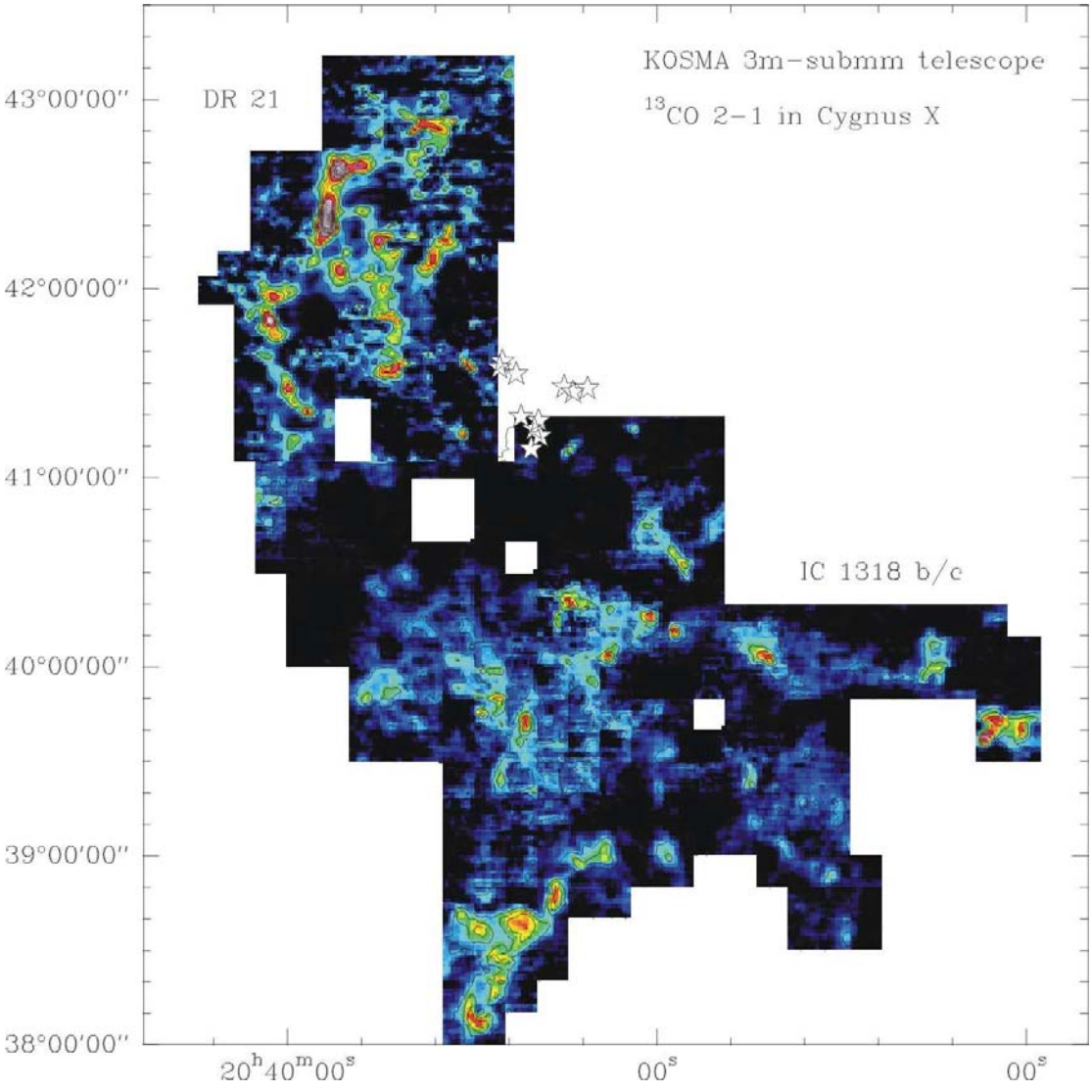


Fig. 3 The large KOSMA map of $^{13}CO2$-1 in the Cygnus-X region

In particular, globular shaped clouds pointing away from the cluster center reveal a close interaction with OB2 in different velocity ranges. This supports a scenario in which Cygnus X is a single, coherent molecular complex at ~1.7 kpc distance that spawned the OB2 cluster, now compressing surrounding filaments and thus leading to further star formation. The clouds then form a shell around the cluster with DR21/W75N being more evolved and closer to OB2 than IC 1318 b/c. This picture challenges the standard view that the large number of objects seen in Cygnus X is a by chance superposition of clouds along the tangent of the local spiral arm (e.g., Wendker et al., 1991). Extending the molecular line surveys at KOSMA and FCRAO is mandatory to confirm our scenario that Cygnus X is a large Strömgren sphere surrounding the Cyg OB2 association. If this proves to be the case, Cygnus X is an unusally rich region of the Milky Way and an exceptional laboratory to study high mass star formation.

The Cygnus X project is a collaboration of R. Simon, H. Jakob, C. Kramer, and M. Miller at Cologne (I. Physikal. Institut) with S. Bontemps, N. Schneider (Observatoire de Bordeaux, France), F. Motte (CEA/Saclay, France), and C. Brunt (FCRAO, Umass, Amherst, USA).

Key words:

Interstellar matter, ISM, PDR, millimeter, submillimeter wave telescope, SIS reciever, HEB, array reciever

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, Center of Astrophysics, Boston, USA, Observertoire de Bordeaux, Astronomy Department Peking University, China, Beijing Astronomical Observatory (BAO), Potechefstroom University, South Africa.

Scientific publications and public outreach 2004 (KOSMA relevant papers only):

Refereed journal articles

Kramer, C., Jakob, H., Mookerjea, B., Schneider, N., Brüll, M., Stutzki, J., Emission of CII, CI, and CO in W3Main *Astron. & Astrophys.* **424**, 887, 2004

Qin, Sheng-Li, Wu, Yue-Fang, Wang, Jun-Jie, Zhao, Gang, Shi Jian-Rong, Miller, M. Star Formation in Molecular Cloud Associated with IRAS 07028-1100, *Chinese Phys. Lett.* **21** 1677, 2004

Conference papers

Brüll, M., Kramer, C., Ossenkopf, V., Simon, R., Stutzki, J., The KOSMA large scale CO survey of clouds in the Galactic Molecular ring *Astrophysics and Space Science* **289**, 3, 255, 2004

Address:

1. Physikalisches Institut
Universität zu Köln
Zülpicher Str. 77
D-50937 Köln

Radioastronomisches Institut
der Universität Bonn
Auf dem Hügel 71
D-53121 Bonn

Contacts:

Jürgen Stutzki (observatory director)
Tel.: +49 221 470 3494
Fax: +49 221 470 5162
e-mail: stutzki@ph1.uni-koeln.de
Martin Miller (station manager)
Tel.: +49 221 470 3558
Fax: +49 221 470 5162
e-mail: miller@ph1.uni-koeln.de
URL: http://www.ph1.uni-koeln.de
http://www.astro.uni-bonn.de