

Project No. : 17004  
 Core Institution in Japan: Nagoya University

JSPS Core-to-Core Program -Strategic Research Networks-  
 FY2007 Research Report

Project No.	17004
Research Theme	Center for advanced research on the interstellar medium in sub-mm waves and gamma rays
Duration of Project	April 1, 2007 – March 31, 2010
Core Institution in Japan	Nagoya University

Implementing Organizations

Country	Japan
Core Institution	Nagoya University
Co-Chair (name and title)	Yasuo Fukui
Number of Cooperating Institutions	5
Cooperating Institutions	National Observatory of Japan, University of Tokyo, Kyoto University, Osaka Prefecture University, Hokkaido University

Country	Germany
Core Institution	University of Cologne
Co-Chair (name and title)	Juergen Stutzki, Professor
Number of Cooperating Institutions	1
Cooperating Institutions	University of Bonn
Matching Fund	University of Cologne: the Ministry of Research in the Federal State of Nordrhein-Westfalen, Operation of the KOSMA / NANTEN2 - observatories

Country	United States
Core Institution	Stanford University
Co-Chair (name and title)	Tsuneyoshi Kamae, Professor
Number of Cooperating Institutions	1
Cooperating Institutions	NASA Goddard Space Flight Center
Matching Fund	Stanford University, GLAST-Large Area Telescope

Country	France
Core Institution	CESR
Co-Chair (name and title)	Jean-Philippe Bernard, Researcher
Number of Cooperating Institutions	4
Cooperating Institutions	IAS, CEA/Saclay, LERMA/Paris, Strasbourg Observatory
Matching Fund	CNES/CNRS, PILOT, GLAST, Herschel, Planck, SPICA-ESI project funds

Country	Australia
Core Institution	University of New South Wales
Co-Chair (name and title)	Michael Burton, Professor
Number of Cooperating Institutions	2
Cooperating Institutions	University of Sydney, Macquarie University
Matching Fund	Australian Research Council, Linkage Infrastructure Equipment & Facilities: A ground station for the NANTEN2 sub-millimetre wave telescope

Country	UK
Core Institution	Cardiff University
Co-Chair (name and title)	Anthony Whitworth, Professor
Number of Cooperating Institutions	0
Cooperating Institutions	
Matching Fund	1. UK's Particle Physics and Astronomy Research Council, Rolling Grant: Unveiling the Hidden Universe 2. Framework Programme 6 of the European Commission, Research Training Network: Constellation

## Result of Program Implementation

The projects have been progressed under the collaboration among the core institutions, University of Cologne in Germany, Stanford University in the USA, CESR in France, University of New South Wales in Australia, and Cardiff University in UK. We have also developed our collaboration with Japanese researchers majoring in the interstellar matter at National Astronomical Observatory in Japan, University of Kyoto, University of Tokyo, Hokkaido University, and Osaka Prefecture University to investigate the promotion of the research in the interstellar matter.

The keys to the joint research activities are; 1. Operation of sub-mm telescope NANTEN2 in Chile, 2. Comparative study of molecular data with gamma-ray data, 3. Hard X-ray imaging observations of galactic center, 4. Statistical study of dust emission in molecular clouds, and 5. Theoretical Physics of Interstellar Medium with Innovative Observations.

NANTEN2 meeting was carried out at University of New South Wales in Australia. The number of participants was 24 including Japanese, Germany and Australian researchers. Observational results with NANTEN2 and Australian telescopes were reported and the future collaborative works and scientific programs were discussed for NANTEN2 operation for the year.

Researchers were sent to various international conferences to present the scientific results by this core-to-core program, such as in "Galaxies in the Local Volume", "Elizabeth and Frederick White Conference on the Magellanic System", "Far infrared 2007", "ASTE Workshop", "The Suzaku X-ray Universe", "Star Formation across the milky way Galaxy", and "The cosmic agitator-magnetic fields in the galaxy".

## Achievements in FY2007 (Self Review)

The development of NANTEN2 is on-going well, leading to a successful second-year submillimeter observations. The observed targets include Galactic star forming regions (B59, B68, Carina, NGC3603, Rosette, RCW103, W28), the Galactic center (SgrB2, Molecular loop), Large/Small Magellanic Clouds (30Dor, N159), nearby galaxies (NGC253, NGC4945, Circinus, M33, M83, M100). Data reduction of the first year's results have been carried out, and three papers were published. Infrared data by Spitzer and molecular/atomic data were precisely compared by Japanese and French partners, and one of the results was published also under a collaboration with SAGE group.

The study of interstellar matter has been progressed greatly both by utilizing the mm data and gamma-ray data. Not only the gamma-ray data by EGRET as we planned at the beginning of the project but also the data by H.E.S.S. has been also studied. The H.E.S.S. data is not yet openly available, but our collaboration makes it possible to start comparing the molecular data with the most recent H.E.S.S. data. Our NANTEN data has been used carefully and restored so that the study to compare with the data in the other wavelengths is on going.

Winter school on the ISM was carried out from February 18 to 22 in 2008 with 41 participants including lectures and young researchers. Four lecturers were invited; Prof. John Dickey (U. of Tasmania): Atomic gas in the ISM, Prof. Robert Benjamin (U. of Wisconsin): Structure of the Milky Way Galaxy, Prof. Gavin Rowell (University of Adelaide): "Very High Energy Gamma-Ray Astronomy", Christian Theis (Wien University): "Galaxies - complex evolving systems", with short lectures by Dr. Bernard, a co-chair of French side. The discussion between the lecturers and young researchers was promoted, and the poster session was organized with short oral presentations for young researchers.

## Future Plan (Measures toward Achieving Research Objectives)

We shall continue our promotion of the project. The scientific meetings as well as the workshops like schools for young researchers shall be organized. The Center for Astrophysical Research from the Southern Hemisphere established in April 2006 at Nagoya University shall support promoting these activities.

We are planning to install a multi-beam sub-mm receiver system to NANTEN2, which will improve the surveying ability of the NANTEN2 by a factor of  $\sim 10$ . This will lead us to achieve the research objectives to understand the physical properties of the interstellar matter (ISM) from low density molecular gas to hot, dense molecular cloud cores, where molecular clouds and stars are formed, respectively. This will be carried out on collaboration with the people from Univ. of Cologne and Univ. of Bonn, Germany.

In parallel to it, we shall deepen our collaboration on the study of molecular clouds interacting with high energetic sources observed by EGRET, H.E.S.S., GLAST and the most recent data from Suzaku with researchers in the USA and Germany. There are already lists of SNRs as well as unidentified gamma-ray sources. We are to compare these sources with NANTEN CO data, and also carry out further observations by NANTEN2 or propose to observe by Suzaku. These studies will give us a better understanding on the mechanism of the high energetic sources to be interacting with the interstellar clouds.

It is important to investigate not only the properties of the interstellar gas but also those of the interstellar dust to have a comprehensive knowledge on the ISM. The studies in optical to infrared wavelengths together with our mm to sub-mm and high energy astronomy will promise our achievement to the goal. Herschel and Planck satellites, which cover infrared to millimeter wavelengths, will be launched soon, and preparation of the collaborative research by using them is undergoing.