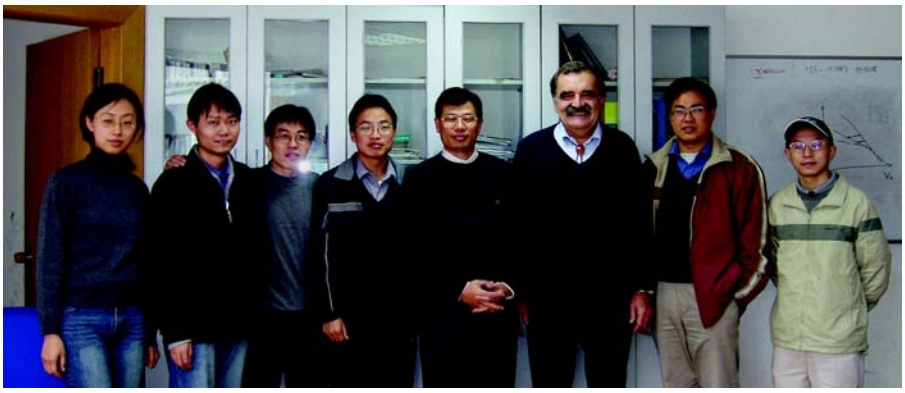
MPS/CAS Partner Group on Cosmology



Professor Gerhard Börner (German Partner, third from right) with the Partner Group headed by Professor Jing Yipeng (fourth from right) in Shanghai .

Shanghai-Garching

The Partner Group does research in cosmology, focussing on the quantitative modeling of the structure and evolution of galaxies and galaxy clusters, the pattern of galaxies and of larger structures.

The usual approach in this field is the dark matter paradigm, *i.e.* the assumption that the basic structures are laid out in a matter component of particles which interact only gravitationally. Numerical simulations of large scale and high resolution are used to follow the evolution of condensations of dark matter particles during cosmological evolution. Analytic models and detailed statistical investigations of astronomical data sets supplement the numerical work.

Reported by Group Leader Jing Yipeng

Present Status

The Partner Group of the Max Planck Institute for Astrophysics (MPA) at Shanghai Astronomical Observatory (SHAO) is actively working in the field of cosmology. Its research receives international recognition and contributes significantly to the scientific output of the MPA. Invited talks at major astrophysics conferences (such as the IAU meeting in Sydney in 2003) and the offer of international collaborations by institutes in Canada, US and Europe (the group has been invited to join the European Galaxy Lensing Project (ANGLES) as the only non-European collaborator) demonstrate that the group has reached a top position internationally.

The basis for this success of the Partner Group is the numerical simulations of structure formation in a cosmological context by Jing Yipeng. The large scale and high resolution of the computations yield a unique data set which leads to new insights on the build-up of density condensations in the universe which eventually develop into galaxies. Thus, the nonspherical shape of such halos, as they are called, has been quantified, and a basic law connecting the mass accretion history with the density profile of dark matter halos has been uncovered. These results have consequences for the basic issues in galaxy formation. A large fraction of the international theoretical and experimental research activity in astronomy and astrophysics is centered on such questions.

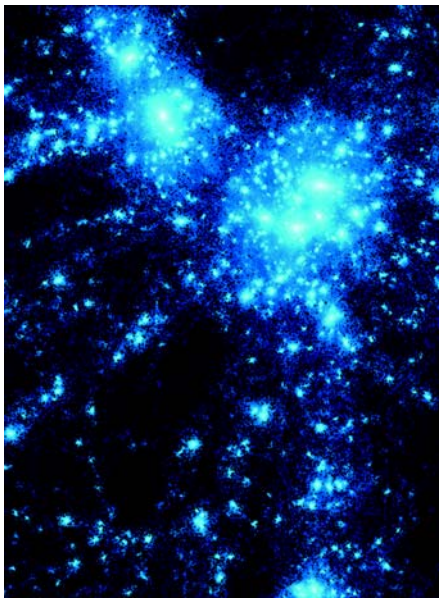
At present the Partner Group is still in the build-up and development process. It should be emphasized that the approach to scientific problems by numerical simulations was completely new to China. In addition, the plan was to start the group with young students. One student has obtained a Ph. D.; others will soon follow.

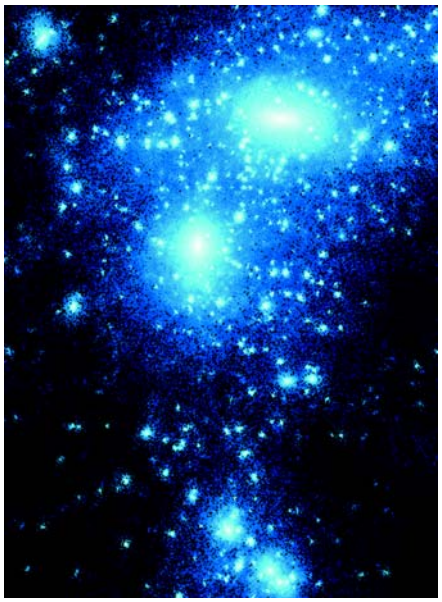
The exchange program we have initiated has proven to be of prime importance for the group and the development of young students and scientists. Students can visit the Max Planck Institute for Astrophysics for periods of three months to one year. In turn, scientists from the MPA are invited to visit Shanghai. The program has been very successful: usually one joint paper appears in an international journal as a result of a visit. It is especially attractive to the young scientists that the administrative formalities are minimized and that repeated visits are the rule. This vigorous exchange program, freed from bureaucratic obstacles, should be continued.

Several workshops on cosmology and astrophysics have been jointly organized: 2000 and 2001 in Shanghai, 2002 in Beijing. In the fall of 2004 another workshop is planned, and in 2005, the final year of this partnership project, an international cosmology conference is planned.

Selected publications

1. Zhao, D. H.; Mo, HJ; Jing, YP; Börner, G (2003) The growth and structure of dark matter haloes *MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY*, 339 (1): 12 – 24
2. Chen, DN; Jing, Y. P. (2002) The angular momentum distribution within haloes in different dark matter models *MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY,* 336 (1): 55 – 65.





Dark matter distribution within dark haloes predicted on the base of computer simulations. Dark haloes are dynamically equilibrium objects in the Universe where visible objects, such as galaxies, reside. The properties of galaxies are shaped by the matter distribution and evolution of dark haloes, thus cosmologists are able to observe dark matter through observing galaxies.

3. Jing, Y. P.; Suto, Y (2002)
Triaxial modeling of halo density profiles with high-resolution N-body simulations
ASTROPHYSICAL JOURNAL, 574 (2): 538 – 553, Part 1

Future Plans

In the field of the natural sciences, the next ten years will be the decade of astrophysics, astronomy and cosmology. This bold statement is supported by several very strong facts: the precise measurements of the anisotropies of the cosmic microwave background show that unknown components called "dark matter" and "dark energy" are responsible for about 95% of the matter and energy density of the universe. These facts must be intimately connected with basic concepts of particle physics, but astronomy is leading the way in the research establishing their properties.

A precise understanding of the properties, the formation and evolution of celestial objects, is an absolute prerequisite to making progress regarding these basic questions. There must be a tight combination of theoretical modeling and precise astronomical observations of the early formation of galaxies, their large scale distribution and their inner structure to find out more about the distribution of dark matter and dark energy and the way these components influence processes in the universe. The research of the Partner Group already covers many of these aspects.

It is quite clear that the planned new surveys and observation campaigns for high redshift galaxies, gravitational lensing fields and large scale detailed galaxy distributions will bring new results for at least the next ten years. It will become necessary to rely on sophisticated theoretical modeling, simply to understand and to interpret these precise observations. In addition, the observational strategies, even down to the planning of the instrumental set-up, will depend on detailed numerical simulations of the expected real situation.

The Partner Group will contribute significantly to future observational projects in China *(e.g.* studies for the LAMOST target strategy) and internationally. This growing participation in joint projects and the widening of the group's scientific goals point to a promising future, if the manpower of the group is also built up considerably.

The installation of a new supercomputer at CAS ensures that the Partner Group remains competitive at the international level in the field of numerical astrophysics.

The MPA will develop in a similar way, so that a continuation of the successful collaboration in a slightly changed format would seem highly desirable. We can imagine that the Partner Group at SHAO will evolve into a research center for theoretical astrophysics and cosmology.

Info

MPS/CAS Partner Group on Cosmology	
Shanghai Astronomical Observatory	
Founding Date	May 2000
Group Leader	Prof. Dr. Jing Yipeng
Max Planck Institute for Astrophysics	
Prof. Dr. Gerhard Börner	
Prof. Dr. Simon White	
Shanghai Astronomical Observatory	
Dr. Zhao Donghai	(Ass. Prof.)
Dr. Lin Weipeng	(Ass. Prof.)
Dr. Shao Zhenyi	(Ass. Prof.)
Kang Xi	(Ph. D. student)
Hou Yonghui	(Ph. D. student)
Chen Dongni	(Ph. D. student)
Li Guoliang	(Ph. D. student)
Zhang Ye	(Ph. D. student)
Scientific Advisory Board Members	
Prof. Dr. Joseph Silk	(Inst. of Astrophysics, U. of Oxford)
Prof. Dr. Katsuhiko Sato	(Theoretical Astrophysics Group, U. of Tokyo)
Prof. Dr. Simon White	(MPI for Astrophysics, Garching)
Prof. Dr. Zhao Junliang	(Shanghai Observatory, CAS)
Prof. Dr. Chen Jiangsheng	(Dept. of Astronomy, Peking U.)
Internet Addresses	
http://www.mpa-garching.mpg.de	
http://center.shao.ac.cn	
ypjing@center.shao.ac.cn	