X-RAY ASTRONOMY

Dr. S. N. Zhang has lead a seven member group (Dr. Yuxin Feng (MIT postdoc, but full-time visiting scientist to Dr. Zhang's group), Mr. Xuejun Sun (UAH research analyst III, on-site at MSFC), Mr. Yongzhong Chen (visiting scholar from IHEP, China), Mr. Jun Lin (UAH graduate student), Mr. Yangsen Yao (UAH graduate student), and Ms. Xiaoling Zhang (UAH graduate student). This group has carried out the following activities: continued data analysis from space astrophysical missions CGRO, RXTE, ASCA and Chandra. Significant scientific results have been produced as results of their work. They discovered the three-layered accretion disk structure around black holes in X-ray binaries; their paper on this discovery is to appear in the prestigious Science magazine. They have also developed a new method for energy spectral analysis of black hole X-ray binaries; four papers on this topics were presented at the most recent Atlanta AAS meeting (all these papers are under revision for ApJ submission). They have also carried Monte-Carlo simulations of X-ray detectors, in support to the hardware development efforts at MSFC. These computation-intensive simulations have been carried out entirely on the computers at UAH. They have also carried out extensive simulations for astrophysical applications, taking advantage of the Monte-Carlo simulation codes developed previously at MSFC and further improved at UAH for detector simulations. One refereed paper and one contribution to conference proceedings have been resulted from this effort. They have also been involved in writing many proposals. The most significant success is winning four proposals of the Astro-E mission (only about 70 US proposals were selected in a stiff competition). Dr. Zhang is also involved as Co-I in some proposed future missions. Currently Dr. Zhang is leading a proposal to NASA, in collaboration with other UAH and MSFC scientists, for a new detector development effort, aiming at producing the best room-temperature semi-conductor X-ray and gamma-ray detectors. Dr. Zhang was one of the organizers of an international meeting in Hong Kong and also gave an invited review at the meeting.

In addition a Physics Department graduate student (Mr. Kim Ong) working under the direction of Professor Z. E. Musielak at the Center for Space Plasma and Aeronomic Research (CSPAR) and Department of Mechanical and Aerospace Engineering and Dr. M. Weisskopf (MSFC) has constructed the first purely theoretical, self-consistent and time-dependent solar wind models using a modified version of the ZEUS code. The models are radially symmetric and the initial atmosphere is magnetized and expanding. The outflow is described by standard Parker's wind solution and the effects of Alfven waves on the outflow are investigated by solving the full set of ideal and nonlinear MHD equations. In contrast to previous studies, no assumptions regarding wave linearity, wave damping and wave-flow interaction are made. The constructed models naturally account for the backreaction of the wind on the waves and for the nonlinear interaction between different types of MHD waves. For a perturbed wave amplitude about 50-100 km/s, results clearly demonstrate that momentum deposition by Alfven waves in the solar wind is sufficient to explain the origin of the fast stream in solar coronal holes. Also, a Physics Department graduate student working under the direction of Professor Z. E. Musielak at the Center for Space Plasma and Aeronomic Research (CSPAR) and Department of Mechanical and Aerospace Engineering has: (a) participated in and supported the scientific development of advanced instruments and experimental techniques for X-ray astronomy; (b) participated in and supported a continuing program of balloon and sounding rocket flights, including flight detector
development, ground support equipment development, pre-flight preparation field support, and
post-flight refurbishment; (c) supported the analysis and interpretation of scientific data from
flight and ground-based experiments; (d) provided scientific and analytical support for AXAF-I
with emphasis in the area of scientific instrument calibration and testing.

Publications and Presentations

“RXTE observations of Cygnus X-3”, McCollough, M. L. and Robinson, C. R and Zhang, S. N.
and Harmon, B. A. and Paciesas, W. S. and Dieters, S. W. and Hjellming, R. M. and Rupen, M.
and Mioduszewski, A. J. and Waltman, E. B. and Ghigo, F. D. and Pooley, G. G. and Fender, R.

“Spectral Transitions in Cygnus X-1 and Other Black Hole X-Ray Binaries, Astrophysical

“The Outbursts and Orbit of the Accreting Pulsar GS 1843-02=2S 1845-024”, Finger, M. H. and
Bildsten, L. and Chakrabarty, D. and Prince, T. A. and Scott, D. M. and Wilson, C. A. and

“Discovery of Correlated Behavior between the Hard X-Ray and the Radio Bands in Cygnus X-
3”, McCollough, M. L. and Robinson, C. R. and Zhang, S. N. and Harmon, B. A. and Hjellming,
R. M. and Waltman, E. B. and Foster, R. S. and Ghigo, F. D. and Briggs, M. S. and Pendleton, G.

“Hard X-Ray Lags in GRO J1719-24”, van der Hooft, F. and Kouveliotou, C. and van Paradijs,

“BATSE Observations of the Piccinotti Sample of Active Galactic Nuclei”, Malizia, A. and
Bassani, L. and Zhang, S. N. and Dean, A. J. and Paciesas, W. S. and Palumbo, G. G. C.,

Van Der Hooft, F. and Kouveliotou, C. and Van Paradijs, J. and Paciesas, W. S. and Lewin, W.
H. G. and Van Der Klis, M. and Crary, D. J. and Finger, M. H. and Harmon, B. A. and Zhang, S.

“The Kiloherz QPO Frequency and Flux Decrease in Aquila X-1 and the Effect of Soft X-Ray

“Strong Aperiodic X-Ray Variability and Quasi-Periodic Oscillationin X-Ray Nova XTE J1550-


Chen, W., Cui, W. and Zhang, S. N., Black Hole Spin Evolution and Cosmic Censorship, AAS/High Energy Astrophysics Division, 1999, 31, 1107

Cui, W., Zhang, S. N., Chen, W. and Swank, J., Quasi-Periodic Oscillations in Black Hole Candidates, AAS/High Energy Astrophysics Division, 1999, 31, 1604


The USRA activities are included in a separate report which is submitted as a sub-contract report in the appendix.

The ISPAE members here are UAH employees only. Gravitational physics research at ISPAE is connected with NASA’s Relativity Mission (Gravity Probe B - GP-B) which will perform a test of Einstein’s General Relativity Theory. GP-B will measure the geodetic and motional effect predicted by General Relativity Theory with extremely stable and sensitive gyroscopes in an earth orbiting satellite. Both effects cause a very small precession of the gyroscope spin axis. The goal of the GP-B experiment is the measurement of the gyroscope precession with very high precision. GP-B is being developed by a team at Stanford University and is scheduled for launch in the year 2001. The related UAH research is a collaboration with Stanford University and MSFC. This research is focussed primarily on the error analysis and data reduction methods of the experiment but includes other topics concerned with experiment systems and their performance affecting the science measurements. The hydrogen maser is the most accurate and stable clock available. It will be used in future gravitational physics missions to measure relativistic effects such as the second order Doppler effect. The HMC experiment, currently