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NASA-CR-199173

**A VISITING SCIENTIST PROGRAM FOR
THE BURST AND TRANSIENT SOURCE EXPERIMENT**

Contract Number:

NAS8-38405

Report Number:

22

Reporting Period:

June 1, 1990 - May 31, 1995

Program Director:

Frank J. Kerr

The University of Maryland

Submitted to:

THE GEORGE C. MARSHALL SPACE FLIGHT CENTER

MARSHALL SPACE FLIGHT CENTER

ALABAMA 35812

By:

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N96-14881

Unclass

G3/90 0064554

(NASA-CR-199173) A VISITING
SCIENTIST PROGRAM FOR THE BURST AND
TRANSIENT SOURCE EXPERIMENT Final
Report, 1 Jun. 1990 - 31 May 1995
(USRA) 80 p

QUARTERLY PROGRESS REPORT
A VISITING SCIENTIST PROGRAM FOR
THE BURST AND TRANSIENT SOURCE EXPERIMENT

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OBJECTIVES

During this project, Universities Space Research Association provided program management and the administration for overseeing the performance of the total contractual effort. The program director and administrative staff provided the expertise and experience needed to efficiently manage the program.

USRA provided a program coordinator and visiting scientists to perform scientific research with Burst and Transient Source Experiment (BATSE) data. This research was associated with the primary scientific objectives of BATSE and with the various BATSE collaborations which were formed in response to the Compton Gamma Ray Observatory Guest Investigator Program. The research involved close coordination and collaboration with the BATSE investigators at MSFC and at the University of Alabama in Huntsville (UAH). The visiting scientists reported to the USRA Program Director on the progress of their research activities. Each visiting scientist's length of service was determined by the USRA Program Director. Some visited MSFC as visiting investigators for a period of a few days to several months.

This project was developed by the investigator at MSFC and research at the investigator's university. Other visiting scientists functioned as remote investigators, in which case an investigator used previously analyzed data obtained from the principal investigator at MSFC, and did most of their work at the home institution.

The typical visiting scientist had a doctorate in physics or high energy astrophysics. The Program Coordinator had similar educational qualifications as well as experience in data systems manipulation and management. The program coordinator assisted visiting scientists with data needed for research and the publication of research results. Separate research projects were also undertaken by the Program Coordinator related to the BATSE.

Scientific Activities

USRA provided administration for workshops, colloquia, the preparation of scientific documentation, etc. and also provided flexible program support in order to meet the on-going needs of MSFC's BATSE program.

A reservoir of scientific and technical advisors was maintained to serve at MSFC on both a continuing and ad hoc basis. The group was called upon for seminars, colloquia, special workshops and conferences. These activities were designed particularly to provide a flexible structure that could react rapidly to the special needs of MSFC.

Missions Operations and Data Analysis Activities

2 USRA performed tasks associated with the recovery, archiving, and processing of scientific data from BATSE. The guidelines and procedures for these activities are outlined in the document "BATSE Mission Operations Manual." The personnel performing these tasks worked with other elements of the BATSE operations team to assure data control and documentation.

Scientific Documentation

4 The results of research in the astrophysics discipline were reported in the form of papers to scientific and technical journals and technical reports and presentations to national and international symposium. A bibliography compiled by Ms. Dannah McCauley, Administrative Assistant on this project, is attached as Appendix 1.

Visiting Scientists and Research Associates

The following Visiting Scientists and Research Associates performed activities on this project. They are listed below in alphabetical order, and their technical reports are attached as Appendix 2.

Ms. Susan Morris Aldridge (December 3, 1990 - May 31, 1995) - Burst and Transient Source Experiment (BATSE) system hardware and software support and database administration.

Mr. James B. Barker (May 26, 1992 - August 7, 1992) Burst and Transient Source Experiment (BATSE) Data Technician and Data Analyst on the GRO

Dr. Dominique Delcourt (February 5, 1991 - January 17, 1992) Particle Transport and Energization in Macroscopic Fields, Comparisons of Theory with In-situ Space Plasma Observations (Burst and Transient Source Experiment - BATSE).

Ms. Katherine Hagedon (July 22, 1991 - May 31, 1995) - Burst and Transient Source Experiment (BATSE) Mission Operations Technician and Data Analyst on the Gamma Ray Observatory (GRO).

Dr. Alan Harmon (June 1, 1990 - March 22, 1991) - Burst and Transient Source Experiment (BATSE) on the Gamma Ray Observatory (GRO) and Radioactivity Analysis of the Long Duration Exposure Facility (LDEF).

Dr. SETHANNE HOWARD (February 4, 1991 - April 15, 1993) Development of Software for the Burst and Transient Source Experiment (BATSE) on the Gamma Ray Observatory (GRO).

Dr. Chryssa Kouveliotou (January 1, 1991 - May 31, 1995) - Burst and Transient Source Experiment (BATSE) software. Configuration of BATSE Spectral Analysis Software (BSAS). An individual list of Dr. Kouveliotou's publications is attached as Appendix 3.

Mr. Burl H. Peterson (May 11, 1992 - May 31, 1995) - Burst and Transient Source Experiment (BATSE) Mission Operations Technician and Data Analyst on the Gamma Ray Observatory (GRO).

Dr. Bradley C. Rubin (June 16, 1990 - May 31, 1995) - Analysis of Gamma Ray Data from the Burst and Transient Source Experiment (BATSE) on the Gamma Ray Observatory (GRO).

Ms. Maitrayee Sahi September 26, 1994 - May 31, 1995) - Burst and Transient Source Experiment (BATSE) Mission Operations Technician and Data Analyst on the GRO.

Dr. Matthew Scott (December 20, 1993 - May 31, 1995) - X-ray Binary Systems, Pulsars and Gamma ray sources.

Dr. Shuang-Nan Zhang (September 8, 1992 - May 31, 1995) - Galactic Center Mapping, Modeling and Long Time Variability Studies using Burst and Transient Source Experiment (BATSE) all sky Gamma-Ray monitor on the Gamma Ray Observatory (GRO).

Mr. Mark Zmyweski (July 15, 1991 - March 31, 1994) Burst and Transient Source Experiment (BATSE) Data Technician and Data Analyst on the GRO.

Consulting/Workshops

A complete list of consultants and their affiliations is attached as Appendix 4.

Subcontracts

Dr. William Henze, Jr. of Teledyne Brown Engineering worked on Subcontract 3305-1 to support data operations for the Burst Transient Source Experiment (BATSE) on the Gamma Ray Observatory (GRO). The period of performance for this subcontract was May 24, 1993, through May 31, 1995. The principal tasks are listed below:

- Organize and support the daily mission operations work;
- Support operational work to include scheduling and coordinating activities by the operations personnel;
- Pursue software development for the purpose of being used in the configuration of the BATSE instrument and for data receipt, data reduction, low-level data processing, data archiving and dissemination;
- Support operational work to include developing and maintaining procedures for instrument commanding, data reduction, data processing, data archiving and data dissemination.

Dr. Michael McCollough from Hughes STX Corporation worked on Subcontract 3305-2 to pursue a program of work for the Burst and Transient Source Experiment (BATSE) and user support related to software, which may include detailed designs and source codes, to be used for data archiving, processing, and resolving errors. The period of performance for this subcontract was May 24, 1993, through May 31, 1995. The principal tasks are listed below:

- Help define FITS formats and oversee the creation of FITS products for use by BATSE users;
- Support BATSE observers in deterring their needs and supplying them with BATSE data products;
- Apply expertise in the areas of FITS creation and data archiving currently in use by the Subcontractor for the ROSAT mission jointly launched and operated by the National Aeronautics and Space Administration (NASA) and Germany;

- Support other scientific tasks as necessary to support the BATSE research efforts.

Financial

Total Contract Value:	\$2,781,590
Funded Value :	\$2,637,787
Available Funding to Contract's Completion:	\$ 143,803

On-Site Employee Location Listing (Reference Section H.7, FAR Clause 52.215.2)

None at physical contract completion due to transition to SUB95-074 under Cooperative Agreement NCC8-65.

UNIVERSITIES SPACE RESEARCH ASSOCIATION

ASTRONOMY & ASTROPHYSICS PROGRAM

BIBLIOGRAPHY

1985-1995

**Compiled by
Dannah McCauley
February 1995**

UNIVERSITIES SPACE RESEARCH ASSOCIATION
 ASTRONOMY AND ASTROPHYSICS PROGRAM
 PUBLICATIONS AND PRESENTATION CONTRIBUTIONS PER VISITING SCIENTIST
 1984-1995

	NCP	IAUC	RJA	BMCP	PA	P	IP	TOTAL
Austin, R.A.			1	2		2		5
Clarke, J.	1	1	7		4	2	5	20
Delcourt, D.C.			3	1		2	1	7
Dent, W.R.F.			1	1				2
Fontenla, J.M.			1					1
Harmon, B.A.		7	3	3	3	27		43
Hagedorn, K.				1	1	2		4
Howard, S.			2	2	2	3		9
Kouveliotou, C.	1	10	28	49	36	88	3	215
Moon, K. - H.			1	3		3		7
Nerney, S.			1					1
Ramsey, B.D.	1		16	6	3	9		35
Rubin, B.C.		7	2	11	11	37		68
Scott, D.M.		5			1			6
Six, F.						1		1
Zhang, S.N.		14	2	8	7	18	5	54
TOTAL	3	44	68	87	68	194	14	478

NCP - NASA Conference Publications
 IAUC - International Astronomical Union Circulars
 RJA - Refereed Journal Articles
 BMCP - Books, Monographs, Conference Publications, etc.
 PA - Published Abstracts
 P - Presentations
 IP - Invited Presentations

N.B. Contributions credited on this chart to individuals are only during their actual tenure as USRA Visiting Scientists. Many have co-authored papers with other USRA visiting scientists both before and after their participation in the program.

UNIVERSITIES SPACE RESEARCH ASSOCIATION

NASA Conference Publications

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International Astronomical Union Circulars

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2. Finger, M. H., Wilson, R. B., Scott, D. M., and Stollberg, M. T. 1994. Second GROJ1008-57 Outburst. *International Astronomical Union Circular*, Number 5959. March 1994. (ES84)
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10. Harmon, B. A., Zhang, S. N., Fishman, G. J., and Wilson-Hodge, C. A. 1993. Hard X-Ray Transient. International Astronomical Union Circular, Number 5890. November 1993. (ES84)
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125. Ramsey, B. D., Elsner, R. F., and Weisskopf, M. C. 1987. The Effect of Gas Purity on the Performance of an X-Ray Detector. 1987 IEEE Nuclear Science Symposium, San Francisco, California, October 21-23, 1987 proceedings. (ES65)
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152. Zhang, S. N., Harmon, B. A., Fishman, G. J., Rubin, B. C., Paciesas, W. S., Grindlay, J. E., and Barret, E. 1994. Search for Hard X-Ray Emission from Galactic Black Hole Candidates with BATSE/CGRO. High Energy Astrophysics Division of the American Astronomical Society, "The Multi-Mission Perspective," November 2-5, 1994, Napa Valley, California. (ES84)

Invited Presentations

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2. Clarke, J. T. 1985. Emission Line Imaging of Dwarf Novae Accretion Disks. The University of Kentucky. (ES62)
3. Clarke, J. T. 1985. The Hubble Space Telescope. The University of California, Berkeley. (ES62)
4. Clarke, J. T. 1985. The Far-Ultraviolet Emissions of the Outer Planets. Space Telescope Science Institute. (ES62)
5. Clarke, J. T. 1985. FUV Imaging of Auroral Emissions From the Outer Planets. Dartmouth College. (ES62)
6. Delcourt, D. C. 1991. Transport and Acceleration of Ions in the Equatorial Magnetosphere. Symposium on Transport and Interaction Processes in Multi-Ion Magnetospheric Plasmas, VII IAGA, Vienna, Austria, August 1991. (ES53)
7. Kouveliotou, C. 1992. BATSE GRB Observations. The University of California, Santa Cruz, June 5, 1992. (ES62)
8. Kouveliotou, C. 1993. BATSE Results on Observational Properties of Gamma Ray Bursts. The Integral Meeting on "The Multi-Wavelength Approach to Gamma Ray Astronomy." Les Diableretes, Switzerland, February 2-5, 1993. (ES66)
9. Kouveliotou, C. 1994. BATSE Observations of Gamma-Ray Bursts. High Energy Astrophysics Division of the American Astronomical Society, "The Multi-Mission Perspective," Napa Valley, California, November 2-5, 1994. (ES84)
10. Zhang, S. N., Harmon, B. A., Fishman, G. J., and Paciesas, W. S. 1993. Imaging with BATSE/CGRO, Jet Propulsion Laboratory, Pasadena, California, November 8, 1993. (ES84)

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12. Zhang, S. N., Harmon, B. A., Fishman, G. J., and Paciesas, W. S. 1993. All Sky Hard X-Ray Imaging with BATSE/CGRO, CalTech, Pasadena, California, November 9, 1993. (ES84)
13. Zhang, S. N., Harmon, B. A., Fishman, G. J., and Paciesas, W. S. 1994. Scientific Results from BATSE/CGRO: Hard Z-Ray All Sky Imaging for the First Time. University of Southampton, United Kingdom, September 23, 1994. (ES84)
14. Zhang, S. N., Harmon, B. A., Fishman, G. J., and Paciesas, W. S. 1994. Hard X-Ray All-Sky Imaging with BATSE/CGRO, "Imaging in High Energy Astronomy," Capri, Italy, September 26-30, 1994. (ES84)

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2. Chakrabarty, D. and Rubin, B. 1994. Discovery of the 18.7 Second Accreting Pulsar GROJ1948+32. *Ap. J. Letters*. (ES84)
3. Dahlem, M., Kreysing, H.-C., White, S. M., Engels, D., Gordon, J. J., Harmon, B. A., Zhang, S. N., Kouveliotou, C., Paciesas, W. S. and Voges, W. RE J1255+266: Detection of an Extremely Bright EUV Transient. *Astronomy and Astrophysics Letters*. (ES84)
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5. Greiner, J., Sommer, M., Bade, N., Fishman, G. J., Hanlon, L. O., Hurley, K., Kippen, R. M., Kouveliotou, C., Preece, R., Ryan, J., Schoenfelder, V., and Winkler, C. The Gamma-Ray Burst GB 920622. *A&A*. (ES84)
6. Harmon, B. A., Wilson, C. A., Fishman, G. J., Paciesas, W.S., Briggs, M. S., Zhang, S. N., Rubin, C. S., and Scott, D. M. Discovery of the Bright, Unusual X-Ray Nova in Scorpius, GRO J1655-40. *Nature*. (ES84)
7. Hartmann, D., Blumenthal, G., Briggs, M., Fishman, G., Hakkila, J., Hurley, K., Horack, J., Kouveliotou, C., Meegan, C., Paciesas, W., and Pendleton, G. Angular Distribution Statistics of Gamma-Ray Bursts: I. Clustering and Recurrence Methods. *Ap. J.* (ES84)
8. Howard, S., Keel, W., Byrd, G. G., and Burkey, J. A Simulation Survey of Tidal Features in Galaxies. *Ap. J.* (ES84)

9. Hurley, K., Dingus, B., Mukherjee, R., Sreekumar, P., Kouveliotou, C., Meegan, C., Fishman, G., Band, D., Ford, L., Bertch, D., Cline, T., Fichtel, C., Hartman, R., Hunter, S., Thompson, D., Kanbach, G., Mayer-Hasselwander, H., von Montigny, C., Sommer, M., Lin, Y., Nolan, P., Michelson, P., Kniffen, D., Mattox, J., Schneid, E., Boer, M., and Niel, M. Extended High-Energy Emission from a Gamma-Ray Burst. *Nature*. (ES84)
10. Hurley, K., Li, P., Laros, J., Fishman, G., Kouveliotou, C., and Meegan, C. The First Search for a Gamma Ray Burst Quiescent Counterpart in the Extreme Ultraviolet with EUVE. *Ap. J.* (ES84)
11. Li, P., Hurley, K., Fishman, G. J., Kouveliotou, C., and Hartmann, D. Stellar Flares and Gamma-Ray Bursts. *Ap. J. Letters*. (ES84)
12. Nemiroff, R., Norris, J., Bonnell, J., Wickramasinghe, W., Kouveliotou, C., Paciesas, W., Fishman, G., and Meegan, C. Gross Spectral Differences Between Bright and Dim Gamma-Ray Bursts. *Ap. J. Letters*. (ES84)
13. Norris, J., Bonnell, J., Nemiroff, R., Scargle, J., Kouveliotou, C., Fishman, G., Meegan, C., and Paciesas, W. Duration Distributions of Bright and Dim Gamma-Ray Bursts. *Ap. J.* (ES84)
14. Sommer, M., Kouveliotou, C., et al. EGRET Observations of GRB930131. *Ap. J. Letters*. (ES84)
15. Zhang, S. N., Harmon, B. A., Fishman, G. J., and Paciesas, W. S. Hard X-Ray All-Sky Imaging with BATSE/CGRO. *Experimental Astronomy*. (ES84)

APPENDIX 2

FINAL REPORT

NAME: Susan Aldridge
CONTRACT: NAS8-38405
PERIOD: December 1990 - May 1995

Activities Performed

In December 1990, I began working in the ES-62 Branch of the Space Science Laboratory as Assistant System Manager for the Burst and Transient Source Experiment (BATSE). My tasks included BATSE Spectral Analysis Software (BSAS) administration, INGRES database administration, and data system software support.

Soon after joining USRA and the BATSE team, I attended the April 5, 1991 launch of STS-37, the Gamma Ray Observatory (GRO).

As BSAS administrator, I installed and upgraded the BSAS software. I represented Marshall Space Flight Center (MSFC) as point of contact for all BSAS issues. Issues were handled through Technical Personnel at Goddard Space Flight Center (GSFC).

As INGRES database administrator, I installed and upgraded the INGRES software. As Site Technical Contact for INGRES support, I interface directly with ASK Corporation's Technical Support personnel on all MSFC BATSE INGRES issues. I have resolved several INGRES procurement and licensing issues. I am also responsible for maintaining data integrity for the INGRES database.

In the area of data systems software support, I am involved in daily system management tasks, such as maintaining disk quotas and resolving general users' issues. I have assisted with several VMS and UNIX operating system upgrades. I have installed various application software packages on both the VMS and UNIX platforms. These packages include:

Kermit - a terminal emulator and file transfer utility

XSpec - a spectral simulation package that will be used for proposals for the Advanced Satellite for Cosmology (ASCA). This package will convert the BATSE data to a format more compatible for the scientific community.

SAOimage - a software package used to display astronomical images in a windows environment.

In November 1994, I was promoted from Assistant BATSE System Manager to BATSE System Manager. With the promotion, my responsibilities increased in managing daily system tasks and ensuring the efficient use of system resources. I have designed and written several software utilities to automate routine system tasks.

I worked with personnel at the Jet Propulsion Lab (JPL) installing a TAE software package for DEC Alpha workstation. Other tasks included reconfiguration and reformatting the mission operations workstation, as well as the restoration of the real-time data operating system.

I have been coordinating the relocation of many of the BATSE team members. This has involved working with the MSFC Network Management Center to configure network connections in new offices.

I have assumed responsibility as Property Manager. This involves all aspects of tracking equipment utilized by the BATSE group. Controlled property is inventoried annually. Annual equipment inventory requires verification and documentation of equipment location and user assignment. Newly acquired equipment, property custodian transfers, and excessed equipment must be tracked.

To maintain my professional knowledge for the benefit of BATSE, I have made every effort to attend seminars and classes. I have attended the Engineering Analysis and Data System II (EADS II) Introduction, Operating System Usage, and X-windows classes. These classes provided an overview of the EADS II distributed computing environment, the use of the UNIX operating system, and the implementation of the X-windows interface. I have also attended an Image Processing class (IPS).

I attended several classes sponsored by SUN Microsystems. These include Solaris operating System Usage, Network Management, and UNIX Shell programming. I also attended a UNIX System Administrator Workshop sponsored by the The University of Alabama in Huntsville.

I have been actively involved in the Georgia INGRES Users Association (GIUA) and the North Alabama INGRES Users Group. I attended meetings for these organizations in Huntsville AL and Atlanta GA. In conjunction with one of the GIUA meetings, I attended a class sponsored by ASK Corporation on Designing High Performance Databases.

Each year, I have been involved with the BATSE Gamma Ray Burst (GRB) Workshop in varying capacities. I have assisted with registration, as well as aided visiting scientists with usage of BATSE computing resources. As a member of the BATSE Workshop Organization Committee, I have coordinated all e-mail responses to the initial workshop announcement.

I have become more involved in administrative issues as BATSE system manager. I interviewed Maitrayee Sahi for the BATSE mission operations and data analyst specialist. Ms. Sahi began work in September 1994.

FINAL REPORT

NAME: Katherine S. Hagedorn

CONTRACT: NAS8-38405

Activities Performed

I began working on the BATSE contract in July of 1991. My first duties were daily operations, processing the daily datasets which are sent from Goddard. Over time those duties expanded to include setting data quality flags, maintaining spectral calibration histories, producing IBDBs (Individual Burst DataBases), burst processing, running software to calculate V/Vmax for bursts and correcting the database of results as necessary, creating FITS format files for several datatypes, and most significantly, pulsar analysis.

I helped a great deal with some not-so-routine data operations as well. In March of 1992, the tape recorders on board CGRO malfunctioned which complicated the daily data operations. I spent a lot of time that month correcting bad times and packet counters in the data before the tape recorders were abandoned in favor of using real-time data only. On several occasions it was necessary to re-run software on historical data due to improvements in the software. And I also helped with the analysis of photomultiplier tube balancing that was performed several times over the course of the mission.

I was responsible for burst processing one or two days per week. For each day, I analyzed the burst triggers to determine whether each trigger was a burst, solar flare, transient source or some other type of event. This included running software to determine the location of the source of the trigger and sending messages to other scientists about the triggers.

In addition to routine data processing and burst processing, I worked with pulsar data, producing light curves for folded-on-board pulsar data. From there I performed spectral analysis on several sources BATSE observed, including the Crab pulsar, PSR1509-58, Her X-1, and A1118-616. I contributed to papers on A1118-616 and PSR1509-58. (See references below.) I also wrote or modified numerous programs to assist with pulsar analysis. On several occasions, I assisted with preparations for presentations at conferences. This involved large amounts of spectral fitting, modifying software to produce publication quality plots and producing light curves of pulsars. Recently, I began a study of Crab pulse profile variations and the effects of atmospheric scattering on the pulse profiles.

Altogether, I have looked at data for over 40 different pulsars, most of which are radio pulsars that BATSE has not detected to date. I tabulated the results for each pulsar in order to determine upper limit flux values for those sources not seen by BATSE.

In the fall of 1994 I examined the FFT pulse search results. I looked for significant signals at different periods and determined the sources based on the period and the detectors in which they were seen. Then I sent mail messages to several scientists summarizing the results. This task is rotated among all members of the pulsar team every few months.

My experience with the BATSE project has been very exciting and enjoyable. Over time, I have become more of a research aide and my duties have expanded to include more challenging and more interesting tasks. This was a great contract to work on and I am looking forward to continuing with the project on the new contract.

Publications

Coe, M.J., et. al., "Multiwaveband study of a major X-ray outburst from the Be/X-ray transient system A1118-616", 1994, *Astronomy and Astrophysics* 289, 784-794.

Ulmer, M.P., et. al., "Gamma-ray and radio observations of PSR B1509-58", 1993, *Astrophysical Journal* 417, 738-741.

FINAL REPORT

NAME: Chryssa Kouveliotou

CONTRACT: NAS8-38405

Activities Performed

Dr. Chryssa Kouveliotou performed research and tasks in the following areas:

- Temporal analysis of the gamma-ray burst light curves
- Publications
- Talks
- Meetings/Workshops

Temporal Analysis of the Gamma-Ray Burst Light Curves:

She performed standard timing analysis techniques to search for periodic oscillations (such as Fourier transformations) and prepared fits to the pulses comprising a grb light curve, in order to decompose them into their constituents and derive statistical properties of the pulses.

Dr. Kouveliotou studied the precursor activity related to GRBs which was detected with BATSE. It has shown that the precursor emission cannot be differentiated from the main episode emission. The results have been submitted by T. Koshut et. al., to Astrophysical Journal. She also began a new project with a UAH graduate student on quantifying the red noise component in GRB light curves.

Study of the Quasi-Periodic Oscillations of Black Hole Candidates:

Dr. Kouveliotou's work on the fast variability of the black hole candidate GRO J1719-24 has been completed in the first level of analysis (data collection and interpretation). This work was presented by Frank Van der Hooft et. al., at the AAS meeting (January 1995) in Tuscon, AZ.

The analysis of the light curve of Nova Sco (GRO J1655-44) has shown that the source exhibits no fast variability; a limit of 5% has been set at the rms value of the source red noise. The results will be reported by D. Crary et. al., at the spring meeting of the APS in Washington DC, April 1995.

A list of Dr. Kouveliotou's publications and papers is attached as Appendix ?.

FINAL REPORT

NAME: Burl H. Peterson
CONTRACT: NAS8-38405
PERIOD: May 11, 1992 thru May 31, 1995

Activities Performed

- Activities performed during this period were processing data, archiving data, spectral calibration, making IBDBs, daily review of the occultation output in search of new sources, burst processing, and sending commands to the spacecraft for repointing and targets of opportunity. I have written several programs to support my different tasks. ReOrientation-Sources-Occultation-Flux (ROSOF), this program determines which sources were bright on a given day. This daily output provides a quick look for the scientist, because at a glance they are able to tell which source is bright or if a source that was bright has begun to decrease in intensity. There are two programs I wrote that make work more productive. BATSE Trigger Enable-Disable (BTED) and BURST-FLARE DB (BFD), these programs have greatly reduce the time it takes to preform these tasks. Over certain regions of the earth the BATSE detectors can be trigger falsely. This makes it very important to disable the triggering mechanism when the satellite is over these regions of the earth. The program BTED perform this task by accumulating triggering enable and disable times and creating a file that is transmitted to the satellite.
- Preparing the Burst-Catalog a program is ran to make Individual-Burst DataBase (IBDB). To process old bursts or solar flares for the IBDB one had to gather information from several location and this was very time consuming. The program BFD gathers this information for you as well as alert you to any special situation you may encounter.
- Create-Flaring DataBase (CFDB) is a program I wrote to create a source database of sources that are flaring. I also, wrote several routine that will be added to the occultation program that will used this database. Finally, I have been processing triggers old and new that could have possible resulted from lightning which are call Terrestrial Gamma Flashes (TGF's). Also, my work with the ROSAT IDL routines have begun to show some results. I have been able to generate maps with the location of the satellite over the surface of the earth at the time of the trigger event. Last, with the new trigger catalog on line and improvements made to the Locburst program, I have began to generate new burst location for the 3B Burst Catalog.

FINAL REPORT

NAME: Brad Rubin

CONTRACT: NAS8-38405

Activities Performed

Dr. Brad Rubin analyzed gamma ray data from the Burst and Transient Source Experiment. He is currently interested in the gamma ray background, observation of astronomical gamma ray sources by Earth occultation, X-ray pulsars, and transient sources.

He has made numerous revisions to his original draft paper on 4U1700-37. These revisions include refined discussions of the flaring behaviors, the binary system parameters, and the possible causes of the orbital period change. In this regard, this is one of only a few high-mass systems for which an orbital period change has been measured. Dr. Rubin has shown that it is of the same order of magnitude as the period change due to mass loss from the system expected on theoretical grounds. However, it is also possible that a non-negligible fraction of the observed change is due to a tidal mechanism. He is preparing a paper for submission to *Astrophysical Journal* on this subject.

Dr. Rubin has set limits on hard x-ray emission from the impact of comet Shoemaker-Levy 9 on Jupiter which were used in conjunction with the ROSAT detection of soft x-ray emission to place spectral constraints on the origin of the radiation. Specifically, this has been used to argue that if radiation belt electrons are the source of the radiation (which is probable) then the typical electron energy must be less than 1 Mev. The results are part of a paper submitted to *Science*.

FINAL REPORT

NAME: Maitrayee Sahi
CONTRACT: NAS8-38405
PERIOD: 26 Sep 1994 - 31 May 1995

Activities Performed

- Trained to do the daily operations work for BATSE data.
- Trained to do BURST PROCESSING for BATSE data.
- Performed daily operations work for the BATSE group, including archival, making of IBDB's (individual burst database) for the BURSTS, TGF(terrestrial gamma ray flash), & SOLAR FLARES.
- Performed monthly and bimonthly operations work which included, tape archival of raw and processed data, archival of GOES plots, and spectral histories.
- Completed work on quality flag check for old BATSE data and rearchival of the new quality flag files for the same data.
- Worked on the project to identify repeater BURSTS in BURST data.
- Started work on redoing the locations for the BURSTS which will be included in the upcoming 3B catalog.
- Worked on the imaging software for the occultation group. Tried various test runs and am now well versed in its usage. Made FITS images from the results of the occultation imaging runs.

FINAL REPORT

NAME: Matthew Scott

CONTRACT: NAS8-38405

Activities Performed

I first joined the BATSE team in December of 1993 and have spent five quarters at the Marshall Space Flight Center now. I first learned how the computer systems work and acquainted myself with the process of analysis of BATSE pulsar data. Specifically, I have been learned how to schedule pulsar observations with BATSE, a chore that must be done every week or two. I also learned how to use BATSE's two pulsar monitoring functions: an FFT monitor

for general detection of new pulsars and an epoch folding monitor for tracking known pulsars. This activity has resulted in the detection of an outburst from the pulsar 4U0115+634 which has not been seen for the past three years. The appearance of 4U0115+634 was reported in an IAU circular. I have been a main author or coauthor on four IAU circulars involving outbursts from the transient pulsars GROJ1008-57, 4U0115+634, GRO J1655-40 and GX1+4. I also wrote some new software to make these duties easier and more efficient.

Other things that I have done were: participating in the discovery of the new X-ray nova GRO1655-40, analysis of the orbit of the newly discovered pulsar GRO J1008-57 I have written several simulation programs for use in testing data analysis methods and for analyzing model time series that are applicable to the real time series displayed by observed pulsars. I have found a method to generate arbitrary power-law noise processes like those seen from accretion powered pulsars. This has not been done before as far as I know. I assisted in the orbital analysis of the pulsar EXO 2030+375 with Mark Stollberg, in the analysis of Cygnus X-1 data with Dave Crary and in the analysis of GRO 1719 data with Chryssa Kouveliotou. I have begun an extensive analysis of the BATSE data accumulated on Her X-1 and continued model development of the pulse shape changes in Her X-1. I also wrote three proposals for GRO Cycle 5, the Astrophysics Theory program and the X-ray Timing Explorer as well as being a Co-I on five other proposals.

FINAL REPORT

NAME: Shuang-Nan Zhang
CONTRACT: NAS8-38405
PERIOD: Sept. 1992 - Mar. 1994

Activities Performed

I joined the USRA in September 1992 as a research scientist to work on the BATSE experiment under contract NAS8-38405. I have made significant contributions to the BATSE experiment during this period.

I developed a new imaging technique -- the earth occultation transform imaging technique and implemented it to the BATSE data analysis. This technique allows the BATSE instrument to make continuous high sensitivity, high angular resolution images at the hard x-ray energies. This new capability was not originally designed or envisioned before I joined the BATSE team and it has enhanced the scientific capability of the CGRO mission significantly. The BATSE instrument has become the first and only hard x-ray all-sky imager.

This new capability has enabled the BATSE team to discover several important x-ray novae, including the now famous relativistic jet source X-ray Nova Scorpius (GRO J1655-40), which is only the second galactic superluminous jet source found in our galaxy. My fast announcement of the discovery of this source (within only a few days of its initial outburst) has allowed unprecedented simultaneous hard x-ray/radio observations of this source and revealed important information about the physical states of this remarkable system. This source has been regarded as one of the most important high energy sources found in the last decade.

I have also improved BATSE's standard occultation software so that it is now much easier to use, works more reliably and efficient and at least 10 times faster than the previous system. With this new package and combining with the new imaging system I have developed, I am able to process a large amount of BATSE data very rapidly and revealed many new scientific results. Among these new results are: discovery of a new binary system of 241 day orbital period - GRO J1849-03; first hard x-ray detections of several x-ray burster systems by BATSE including the discovery of a hard state outburst from an X-ray burster 4U 1608-522 (first solid observational evidence of spectral break and comptonization of soft x-ray photons by very hot plasma); hard x-ray detection of the 30.5 day disk precession and 1.4 day binary orbit eclipse from LMC X-4, possible discovery of the 26.5 day modulation of hard x-ray from 2CG135+1 (a mystery in gamma-ray astronomy for two decades); first hard x-ray detections of Seyfert II galaxies by BATSE; possible first hard x-ray detections of some unidentified EGRET gamma-ray sources, etc.

The new imaging technique has also helped significantly the data analysis of many sources detected by BATSE, including 3C273, GRS 1915+104, Nova Muscae, GRO J1719-24 (discovered by the new imaging technique), GRO J1008-57, GRS1009-45, 4U 1543-47, 1E 1740-29, GRS 1758-258, GX 354+0, 1145-619, NGC 4151, Cyg X-1, Cyg X-3, AQL X-1, Crab Nebula, GROJ0422+32, GX 1+4, etc. As an on-going study, we are also expanding the number of sources we actively study with the help of the new imaging technique and the new occultation analysis software.

During the two and half years period, I have lead-authored three refereed papers, numerous IAU circulars, conference papers and abstracts. I have also co-authored many publications. I have also been invited to make presentations at one international conference (Capri, Italy in 1994) and at several institutions (Caltech, JPL, USC, Southampton). I was the PI of one Cycle 4 and a co-investigator of nearly a dozen Cycle 4 proposals. I am the PI of three Cycle 5 and co-investigator of about 10 Cycle 5 proposals. I am currently proposing for three XTE studies as the PI and several XTE studies as a co-investigator. For the forthcoming 3rd Compton Symposium I have submitted three papers as the lead-author and more than 10 papers as a co-author.

Chryssa Kouveliotou

PUBLICATIONS

Refereed Journals:

In-Progress/Submitted:

1995, Searching for the 3rd Soft Gamma Repeater, SGR1900+14 (K. Hurley, P. Li, S. Kulkarni, D. Frail, et al), *Advances in Space Research* (24th ICRC, August 28- September 8, Rome, Italy).

1995, Gamma-Ray Burst Precursor activity as observed with BATSE, (T. Koshut, C. Kouveliotou, W. Paciesas, J. van Paradijs, G. Pendleton, M. Briggs, G. Fishman, C. Meegan), submitted *ApJ*.

1995, Attributes of Pulses in Bright BATSE GRBs, (J. Norris, R. Nemiroff, J. Bonnell, J. Scargle, C. Kouveliotou, W. Paciesas, C. Meegan, G. Fishman), submitted *Ap. J*.

1994, Cross-calibration of temporal profiles and spectra in bright and dim GRBs with cosmological models, (J. Norris, R. Nemiroff, J. Scargle, S. Davis, C. Kouveliotou, G. Fishman, C. Meegan, W. Paciesas, W. Wickramasinghe), submitted, *Advances in Space Research*.

1994, BATSE observations of the Large-Scale Isotropy of Gamma-Ray Bursts, (M. Briggs, W. Paciesas, G. Pendleton, C. Meegan, G. Fishman, J. Horack, M. Brock, C. Kouveliotou, D. Hartmann, J. Hakkila), submitted *ApJ*, December.

1994, Angular distribution statistics of gamma-ray bursts: I. clustering and recurrence methods (D. Hartmann, G. Blumenthal, M. Briggs, G. Fishman, J. Hakkila, K. Hurley, J. Horack, C. Kouveliotou, C. Meegan, W. Paciesas, G. Pendleton), submitted, *Ap J*.

1994, The Gamma-Ray Burst GB 920622 (J. Greiner, M. Sommer, N. Bade, G. J. Fishman, L. O. Hanlon, K. Hurley, R. M. Kippen, C. Kouveliotou, R. Preece, J. Ryan, V. Schoenfelder, C. Winkler), submitted to *A & A*.

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1995, The first search for a gamma ray burst quiescent counterpart in the extreme ultraviolet with EUVE, (K. Hurley, P. Li, J. Laros, G. Fishman, C. Kouveliotou, C. Meegan), *ApJ.*, 20, May.

1995, BATSE observations of GRB spectra. II. Peak energy evolution in bright, long bursts, (L.A. Ford, D.L. Band, J.L. Matteson, M. Briggs, G. Pendleton, R. Preece, W. Paciesas, B. Teegarden, D. Palmer, B.

- Schaefer, T. Cline, G. Fishman, C. Kouveliotou, C. Meegan, R. Wilson, J. Lestrade), *Ap. J.*, 439, 307-321.
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- 1994, A Search for the Radio Counterpart to the 1994 March 1, Gamma-Ray Burst (D. A. Frail, S. R. Kulkarni, K. C. Hurley, G. J. Fishman, C. Kouveliotou, C.A.Meegan, M. Sommer, M. Boer, M. Niel, T. Cline), *ApJL*, 437, L43 - L46.
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- 1994, The continuum spectral characteristics of gamma-ray bursts observed with BATSE (G. N. Pendleton, W. S. Paciasas, M. S. Briggs, R. S. Mallozzi, T. M. Koshut, G. J. Fishman, C. A. Meegan, R. B. Wilson, A. Harmon, and C. Kouveliotou), *ApJ*, 431, 416-424.
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- 1994, BATSE results on Observational Properties of Gamma-Ray Bursts (C. Kouveliotou), *ApJ Suppl. Series*, 92, 637.
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