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Annual Progress Report
for the period
15 November 1998 - 14 May 2000
for NASA Grant
NAG5-3524

Studies of the Hot Interstellar Medium and Halo of our Galaxy:
Spatial Structure and Spectral Characteristics of the Low Energy X-ray Background

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under NASA's Long Term Space Astrophysics Program (LTSA)

1. Project Overview

The goal of this project is to extend previous studies of the spatial structure and spectral characteristics of the X-ray background in the energy range $\sim 70 - 1000$ eV. The soft X-ray background originates from hot phases of the interstellar medium and the Galactic halo. This hot matter is not uniformly distributed, but shows quite different intensities and spectral ratios in different directions on the sky.

We wish to constrain the distances to the various hot interstellar regions, and to constrain their spectral emission parameters. These are necessary steps toward understanding the origin and evolution of the hot phases of the interstellar medium and their role in the evolution of our galaxy. The program uses data primarily from the ROSAT, DXS, ASCA and Chandra orbiting missions, and secondarily from the EUVE and ALEXIS missions. In addition, data are used from University of Wisconsin sounding rocket flights, and from the ground-based WIYN telescope.

2. Progress During Year Three

A major effort in year three was the work of Jeff Morgenthaler and myself on the response of the DXS instrument. We continued to improve the accuracy of the DXS wavelength scale and area-solid angle product. Using these revisions, we updated the XSPEC-compatible response matrices. We also continued the analysis of DXS data, with emphasis on fitting models to the spectra in the 44 - 84 Angstrom range that were obtained from the Galactic plane in the third quadrant of the Galaxy. Acceptable fits are not obtained using standard Raymond & Smith or Mewe & Kaastra thermal equilibrium models, even allowing the abundances to vary (Sanders et al. 1996). Other work that was done with the DXS data was to fill in some data where telemetry dropouts had eliminated them, and to incorporate into the DXS software the ability to deal with vignettted data. The latter should allow a 20% increase in the usable DXS when it is operational.

The paper presenting the DXS spectra and summarizing the analysis described above was completed and was submitted to the *Astrophysical Journal* for publication. It has been refereed, and received a few suggestions for improvement, and one suggestion that requires substantial work. It will be re-submitted in mid-July 2000.

Work with Steve Snowden continued on a catalog of shadows in the 1/4 keV soft X-ray diffuse background that were identified by comparing ROSAT all-sky survey maps to DIRBE-corrected IRAS 100-micron maps. The results of this investigation were submitted for publication to *ApJ Supplements* and will appear in print within the month (July 2000).

Work continued with Snowden and Jay Lockman on the ROSAT XRT/PSPC data towards the cloud complex in Ursa Major that shows X-ray shadows, and we have reduced a number of the pointed ROSAT observations and two interferometric H I observations towards those clouds. These results will be written up in year four.

I again had further discussions with Keith Gendreau in preparation for ASCA spectral studies of the diffuse background, but Keith found himself increasingly occupied with Astro-E issues. Now that Astro-E swims with the fishes, Keith may have more time for this effort.

Work with Keivan Stassun to reduce B, V, and R band images taken on the Kitt Peak 0.9-m telescope in January 1998 of an X-ray shadowing cloud in Ursa Major has not progressed as I thought due to Keivan getting bogged down in working on his PhD thesis. The goal is to select stars suitable for use with the WIYN telescope multi-object

spectrograph (MOS) to look for interstellar absorption lines that would constrain the distance to the cloud. Keivan will have more time as a post-doc in the next few months.

I worked with Dan McCammon to help with his analysis of the third XQC sounding rocket data. This is a micro-calorimeter observation of the diffuse X-ray background in the 0.1 - 3 keV range from a 30° circle around galactic coordinates $(l,b) \sim (90^\circ, +60^\circ)$. It clearly shows the interstellar O VII line, which can be used with the upper limit on the O VIII line to constrain the temperature of the emitting plasma. These data do not show evidence for iron lines, however.

3. Research Plans for Year Four

Research plans for the coming year continue to be essentially as outlined in the original proposal and described in last year's progress report. The primary activities are to focus on the ROSAT analyses, the DXS analysis, and the Chandra analysis while maintaining a modest level of effort in the ASCA analysis, and the WIYN observations. The major change is that the time originally planned to be used for the analysis of CUBIC data will be used for AXAF data analysis, with small amounts distributed among the other space-based observation sets.

3.1 DXS (30%)

The analysis of DXS data will continue for determining useful spectral parameters for the diffuse background emission from the Galactic plane in the third quadrant of the Galaxy. I will be working with D. Liedahl, R. Edgar, and Jeff Morgenthaler to continue development of improved line emission models, incorporating new and improved calculations of Mg, Si, and S L-shell lines by Liedahl. The second DXS paper will deal specifically with fits using these new line calculations. We will also be collaborating with Randall Smith to fit DXS data to his models of 10⁶-year-old blast waves, which also incorporate reheated cavities, dust and varying thermal conduction. These models must be updated to include the new line calculations from Liedahl. We will also perform simultaneous fits of DXS data with overlapping ROSAT data and XQC data using the improved models when they are available.

3.2 ROSAT (30%)

I will continue the existing collaborations for this work with Jay Lockman and Steve Snowden. We will continue comparisons of ROSAT XRT/PSPC data with existing IRAS 100 micron data, H I 21-cm survey data, and the more recent interferometric data on selected clouds, to quantify how the X-ray background intensity features are related to cloud structures. The initial focus is the clouds in the Ursa Major region, but we will also analysis other clouds with shadows, or obtain upper limits to clouds with no shadows.

3.3 AXAF (20%)

I submitted a proposal for observations using the ACIS detector on the Chandra X-ray Observatory (AXAF) to study diffuse emission from face-on galaxies, and was awarded one 40 ks observation of NGC 3184. This observation was performed in January 2000, and we received the data in April 2000. In addition, a supernova went off in this galaxy in late 1999, and additional 20 ks ToO was obtained in March 2000. A small amount of analysis has been done to date, and it reveals both a general diffuse glow from the galaxy as well as a number of sources, but we have not yet determined if the sources are truly diffuse. We anticipate that the bulk of the analysis of these data sets will be performed

during the upcoming year. The analysis will be complicated a bit by having two separate observations with different roll angles, and by the lack of useful software for analyzing diffuse data.

3.4 ASCA (8%)

In collaboration with K. Gendreau, I plan to use ASCA data from selected deep pointings around the sky to better understand the ~ 400 eV - 1000 eV diffuse background emission. For those ASCA data that overlap ROSAT data, simultaneous fits will be analyzed. Reconciling the apparent differences between the diffuse background spectral parameters found recently by ASCA (Chen, Fabian, and Gendreau 1996) and those found by HEAO 1 is especially critical for understanding the extragalactic background. Now that ASCA has quite an extensive archive of deep pointings, many targets are available for this work.

3.5 WIYN(5%)

I plan to continue to use the WIYN telescope, with its multi-object spectrograph (MOS), to determine distances to the most important clouds, as identified from the ROSAT work. I will continue existing collaborations for this work with B. Wakker and B. Savage. I anticipate obtaining distance information to several clouds this year.

3.6 Sounding Rockets (5%)

In collaboration with M. Juda, J. Bloch, R. J. Edgar, D. McCammon and R. Smith, I plan to use existing Wisconsin sounding rocket data to perform pulse height fits to boron-window and beryllium-filter data previously analyzed only through broad-band count rates. We will also perform simultaneous fits to overlapping DXS data. A fair amount of reprocessing of 10 - 15 year old sounding rocket data will be necessary for this. For year three, the rest of these old data will be read onto disk and reformatted so that photon extraction routines can create photon event files which can be sorted and binned for use by XSPEC.

3.7 ALEXIS/EUVE/CHIPS (2%)

I will continue my existing collaboration with J. Bloch for the ALEXIS work. A draft first ALEXIS paper has been produced without my involvement, but Jeff and I are planning to work together on a second paper. I also have had and will continue to have conversations with Mark Hurwitz and Randy Kimble about using DXS results to constrain models of the diffuse background that may be useful for analysis of the CHIPS data.

4. References

- Sanders, W. T., Edgar, R. J., Kraushaar, W. L., McCammon, D., Morgenthaler, J. P. 2000, "Spectra of the 1/4-keV X-ray Diffuse Background from the Diffuse X-ray Spectrometer Experiment" ApJ, in press
- Sanders, W. T., Edgar, R. J., & Liedahl, D. A. 1996, "DXS Spectra of the 0.25 keV Diffuse Background" in Röntgenstrahlung from the Universe, Proceedings of the International Conference on X-ray Astronomy and Astrophysics, (Würzburg, 25-29 September 1995), H. Ulrich Zimmermann, Joachim E. Trümper & Harold Yorke, eds., MPE Report 263, 339
- Snowden, S. L., Kuntz, K. D., Freyberg, M. J., & Sanders, W. T. 2000, "A Catalog of Soft X-ray Shadows, and more Contemplation of the 1/4 keV Background" ApJS, in press

NASA Astrophysics Program
 Year 4
 15 May 2000 - 14 May 2001

	<u>Hours</u>	<u>Rate</u>	<u>Cost</u>
I. Labor and Fringe Benefits			
a) PI - W. Sanders	1,186	61.44	72,864
b) Res.Assoc. - J. Morgenthaler	361	26.12	9,430
Subtotal			\$82,294
II. Travel			4,552
a) San Diego - SPIE Mtg. July 2000			1,380
b) Honolulu - HEAD Mtg. Nov. 2000			1,820
c) San Diego - AAS Mtg. Jan 2000			1,380
Subtotal			4,580
III. Publications			
a) Paper 1: 20 pages @\$115/pg.			2,300
b) Paper 2: 10 pages @\$115/pg.			1,150
c) Paper 3: 10 pages @\$115/pg.			1,150
Subtotal			4,600
IV. Materials			501
V. Computer Services			0
VI. SSEC Indirect Cost at 44%			42,473
VII. Capital Equipment			0
TOTAL			<u>\$139,000</u>

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Cheryl E. Gest
Cheryl E. Gest, Admin. Officer
Research & Sponsored Programs

CERTIFICATIONS REGARDING LOBBYING; DEBARMENT, SUSPENSION AND OTHER RESPONSIBILITY MATTERS; AND DRUG-FREE WORKPLACE REQUIREMENTS

Applicants should refer to the regulations cited below to determine the certification to which they are required to attest. Applicants should also review the instructions for certification included in the regulations before completing this form. Signature of this form provides for compliance with certification requirements under 34 CFR Part 82, "New Restrictions on Lobbying," and 34 CFR Part 85, "Government-wide Debarment and Suspension (Nonprocurement) and Government-wide Requirements for Drug-Free Workplace (Grants)." The certifications shall be treated as a material representation of fact upon which reliance will be placed when the Department of Energy determines to award the covered transaction, grant, or cooperative agreement.

I. LOBBYING

The undersigned certifies, to the best of his or her knowledge and belief, that:

- (1) No Federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any Federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.
- (2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form-LLL, "Disclosure Form to Report Lobbying," in accordance with its instructions.
- (3) The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers (including subcontracts, subgrants, and contracts under grants, loans, and cooperative agreements) and that all subrecipients shall certify and disclose accordingly.

This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by section 1352, title 31, U.S. Code. Any person who fails to file the required certification shall be subject to a civil penalty of not less than \$10,000 and not more than \$100,000 for each such failure.

2. DEBARMENT, SUSPENSION, AND OTHER RESPONSIBILITY MATTERS

- (1) The prospective primary participant certifies to the best of its knowledge and belief, that it and its principals:
 - (a) Are not presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from covered transactions by any Federal department or agency;
 - (b) Have not within a three-year period preceding this proposal been convicted of or had a civil judgment rendered against them for commission of fraud or a criminal offense in connection with obtaining, attempting to obtain, or performing a public (Federal, State or local) transaction or contract under a public transaction; violation of Federal or State antitrust statutes or commission of embezzlement, theft, forgery, bribery, falsification or

destruction of records, making false statements, or receiving stolen property;

- (c) Are not presently indicted for or otherwise criminally or civilly charged by a governmental entity (Federal, State or local) with commission of any of the offenses enumerated in paragraph (1)(b) of this certification; and
 - (d) Have not within a three-year period preceding this application/proposal had one or more public transactions (Federal, State or local) terminated for cause or default.
- (2) Where the prospective primary participant is unable to certify to any of the statements in this certification, such prospective participant shall attach an explanation to this proposal.

3. DRUG-FREE WORKPLACE

This certification is required by the Drug-Free Workplace Act of 1988 (Pub. L. 100-690, Title V, Subtitle D) and is implemented through additions to the Debarment and Suspension regulations, published in the Federal Register on January 31, 1989, and May 25, 1990.

ALTERNATE I (GRANTEES OTHER THAN INDIVIDUALS)

- (1) The grantee certifies that it will or will continue to provide a drug-free workplace by:
 - (a) Publishing a statement notifying employees that the unlawful manufacture, distribution, dispensing, possession, or use of a controlled substance is prohibited in the grantee's workplace and specifying the actions that will be taken against employees for violation of such prohibition;
 - (b) Establishing an ongoing drug-free awareness program to inform employees about:
 - (1) The dangers of drug abuse in the workplace;
 - (2) The grantee's policy of maintaining a drug-free workplace;
 - (3) Any available drug counseling, rehabilitation, and employee assistance programs; and
 - (4) The penalties that may be imposed upon employees for drug abuse violations occurring in the workplace;
 - (c) Making it a requirement that each employee to be engaged in the performance of the grant be given a copy of the statement required by paragraph (a);
 - (d) Notifying the employee in the statement required by paragraph (a) that, as a condition of employment under the grant, the employee will:

- (1) Abide by the terms of the statement; and
- (2) Notify the employer in writing of his or her conviction for a violation of a criminal drug statute occurring in the workplace not later than five calendar days after such conviction;

(e) Notifying the agency, in writing, within ten calendar days after receiving notice under subparagraph (d)(2) from an employee or otherwise receiving actual notice of such conviction. Employers of convicted employees must provide notice, including position title, to every grant officer or other designee on whose grant activity the convicted employee was working, unless the Federal agency has designated a central point for the receipt of such notices. Notice shall include the identification number(s) of each affected grant;

(f) Taking one of the following actions, within 30 calendar days of receiving notice under subparagraph (d)(2), with respect to any employee who is so convicted:

(1) Taking appropriate personnel action against such an employee, up to and including termination, consistent with the requirements of the Rehabilitation Act of 1973, as amended; or

(2) Requiring such employee to participate satisfactorily in a drug abuse assistance or rehabilitation program approved for such purposes by a Federal, State, or local health, law enforcement, or other appropriate agency;

(g) Making a good faith effort to continue to maintain a drug-free workplace through implementation of paragraphs (a), (b), (c), (d), (e), and (f).

(2) The grantee may insert in the space provided below the site(s) for the performance of work done in connection with the specific grant:

Place of Performance:
(Street address, city, county, state, zip code)

1225 W. Dayton St.

Madison, WI 53706

Dane County

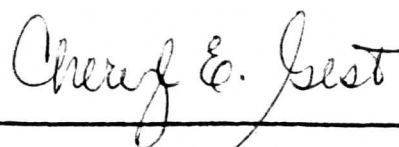
Check if there are workplaces on file that are not identified here.

ALTERNATE II (GRANTEES WHO ARE INDIVIDUALS)

(1) The grantee certifies that, as a condition of the grant, he or she will not engage in the unlawful manufacture, distribution, dispensing, possession, or use of a controlled substance in conducting any activity with the grant.

(2) If convicted of a criminal drug offense resulting from a violation occurring during the conduct of any grant activity, he or she will report the conviction, in writing, within 10 calendar days of the conviction, to every grant officer or other designee, unless the Federal agency designates a central point for the receipt of such notices. When notice is made to such a central point, it shall include the identification number(s) of each affected grant.

As the duly authorized representative of the applicant, I hereby certify that the applicant will comply with the above certifications.

NAME OF APPLICANT Board of Regents of the University of Wisconsin System	PR/AWARD NUMBER AND/OR PROJECT NAME NAG5-3524
PRINTED NAME AND TITLE OF AUTHORIZED REPRESENTATIVE Cheryl E. Gest, Administrative Officer	
SIGNATURE 	DATE 7/10/00