

IN-93-21
7-CIT
209451
12P

COSMIC X-RAY PHYSICS

Grant NAG 5-629

D. McCammon, Principal Investigator

W. L. Kraushaar, Co-Investigator

D. P. Cox, Co-Investigator

W. T. Sanders, Co-Investigator

ANNUAL PROGRESS REPORT

to

THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

January 1, 1990 - December 31, 1990

Submitted by

The Space Physics Group

Physics Department
The University of Wisconsin, Madison
Madison, Wisconsin 53706

January 1991

(NASA-CR-195219) COSMIC X RAY
PHYSICS Annual Progress Report, 1
Jan. - 31 Dec. 1990 (Wisconsin
Univ.) 12 p

N94-27420

Unclas

G3/93 0209451

"COSMIC X-RAY PHYSICS" (NAG 5-629) ANNUAL PROGRESS REPORT

I. THE SOFT X-RAY BACKGROUND

For the first part of the year, Steve Snowden continued his work with the scientific staff of the Max-Planck Institut in preparation for using the data from the German X-ray astronomy satellite, ROSAT, to help in the analysis of our sounding rocket sky survey data. On 1 June 1990, ROSAT was launched, and Snowden began work with the Max-Planck staff on the reduction and preliminary analysis of the ROSAT sky survey data.

Mike Juda, following up on his Ph. D. thesis research, which involved the analysis of our May 1984 and February 1986 sounding rocket flights (17.020 and 27.103), completed his work on the limits on absorbing material within the local cavity which will be published in the Astrophysical Journal in 1991. He found that for a model in which the bulk of the observed soft X-ray emission originates in a uniform low-density region surrounding the Sun, the 2-sigma upper limit on the HI column density over an average path through the local emitting region is $7.8 \times 10^{19} \text{ cm}^{-2}$. If the average path length is $\sim 100 \text{ pc}$, then clouds similar to the one in which the Sun is embedded (density $\sim 0.1 \text{ cm}^{-3}$) could still have a filling factor as large as 25%.

Brad Edwards, completed his Ph. D. thesis, which included his analysis of our most recent (6 December 1988) sounding rocket flight. He found that there is at least one direction on the sky, towards galactic coordinates (132, -69), where the ratio of the Be band count rate to the B band count rate differs from the value found in other parts of the sky. He interprets this as possibly due to absorption of the soft x-ray background by an

intervening interstellar cloud. These results were presented by Edwards et al. at the AAS meeting in January in Washington, DC.

Edwards' spectral analysis of the Be band data found poor agreement between the measured pulse height distribution and that predicted to be emitted from a hot plasma in ionization equilibrium with solar abundances of the elements. Better agreement with the observed data was obtained when the abundance of iron in the model was reduced.

II. NEW SOUNDING ROCKET PAYLOAD: X-RAY CALORIMETER

Progress was made in the mechanical and thermal designs of the sounding rocket payload, particularly the cryostat design. The mechanical design involved modeling the ADR as a system of three damped springs and four masses. The first spring system connects the rocket skin and the the ADR. The second spring system is between the vacuum jacket of ADR and the liquid helium can and consists of two G-10 cylindrical shells. The third spring system is the Kevlar fibers which connect the helium can to the cold stage. Using the finite element analysis method, we calculated the displacement and stress distribution, and the resonant frequencies.

Several mechanical tests were performed. We tested the shear strength of the Armstrong Epoxy A-12, which is used to make joints between aluminum and G-10, and we tested the tensile strength of the Kevlar 49 fiber.

The thermal design involved constructing and running a thermal model of the ADR to determine its thermal properties. In the ADR, we plan to use two radiation shields and multilayer insulation (crinkled aluminized mylar) outside shields. The calculations are done using the "SPICE" in-circuit emulator program running on a main-frame computer located at the Physical

Sciences Laboratory in Stoughton, Wisconsin. Associated with the thermal design effort was determining the emissivity and conductivity appropriate at low temperature for the materials used in the ADR. The efficiency of the vapor cooling is the least well-determined factor in the whole thermal design, and after reviewing the available literature, we made a special dewar to measure the efficiency. The results were submitted for publication to RSI and will appear in 1991.

Juda continued his efforts to refine the processing techniques for making thin calorimeters suitable for the sounding rocket payload, and well as work on techniques for making more advanced detectors that would be suitable for large-format imaging arrays.

A paper was presented by Juda et al. at the Albuquerque AAS meeting in June describing the current design of the sounding rocket payload.

III. THEORETICAL STUDIES

The picture we have of the diffuse ISM is being altered dramatically as a consequence of recent observational studies and the theoretical effort we are supplying to draw them into focus. The medium is characterized by a much larger role for diffuse warm gas, with a very large scale height and significantly larger nonthermal pressure than previously appreciated. This strongly affects our understanding of galactic formations, superbubble evolution, high stage ions, magnetic field generations, and the general pervasiveness of hot gas in the medium.

Jon Slavin finished his thesis on diffuse gas in the interstellar medium - studies involving coupled ionization, radiation and dynamics. The first part, which was published in the *Astrophysical Journal* in 1989, is a

study of the consequences of a conductive boundary on the Local Cloud, the warm ($T \approx 8000 \text{ K}$), low density ($n \approx 0.1 - 0.2 \text{ cm}^{-3}$) region immediately surrounding the Sun. The second part presents the results of a one-dimensional (spherically symmetric) numerical simulation of the evolution of a supernova remnant in a homogeneous medium with a 5 micro-Gauss magnetic field and a density of 0.2 cm^{-3} . He found that the evolution of the remnant, once it has become radiative, differs in several significant ways from that predicted for the equivalent field-free case. Most importantly the hot bubble in the interior occupies only a small fraction of the shocked volume, the remainder in a thick shell of slightly compressed material.

Warren Miller, continued his work on a project to determine the theoretical pattern of the diffuse ISM ionization structure due to OB stars in the solar neighborhood.

Edgar continued his efforts in modeling individual and multiple supernova explosions to simulate the formation of the Local Bubble and to compare the resulting x-ray spectra with soft x-ray background data. Work was begun on efforts to incorporate into the plasma modeling programs the effects of dust destruction, non-Maxwellian velocity distributions, and magnetic fields. He also collaborated with Savage and others in the Astronomy department in studies of interstellar Al III away from the galactic plane, and of molecules in the plane towards the Gum Nebula.

Cox presented a paper on the characteristics of the diffuse interstellar medium at IAU Symposium No. 147 in Grenoble, and in Leiden at IAU Symposium No. 144, he presented his current ideas relating the hot gas of the disk and the hot gas of the halo. He spent the fall semester in

Saclay, France as a Visiting Professor of Astrophysics at the Centre d'Etudes Nuclaires. While there he learned more about interstellar magnetic fields and presented several colloquia and seminars on the diffuse interstellar medium.

STAFF

January 1, 1990 to December 31, 1990

Professors

Donald P. Cox
William L. Kraushaar ✓
Dan McCammon

Senior Scientist

Wilton T. Sanders ✓

Research Associate

Mike Juda *
Steve Snowden

Research Assistants, Graduate Students

Barbara Armstrong **
Wei Cui
Brad Edwards δ
Marco Martos
Warren Miller **
Paul Plucinsky
Jon Slavin
Chris Snedeker
Jiahong Zhang

Secretary

Mildred Brunner ⊕

Student Hourly Helpers

Mark Ericksson *
Karin Fassnacht *
Erik Guckel *
David Harriman *
Janelle Joers
Johann Loschnigg *
Steve Nahn *
Jason Polzin *
Akbar Sayeed *
Bobbi Jo Seul
Kirsten Vaubel

✓ Supported totally or in part by DXS contract NAS 5-26078

* Supported totally or in part by NASA grant NAG 5-594

** Student in Department of Astronomy

⊕ Half-time position, funded by this grant, by the University, and by NSF grant AST-88113467

δ Supported partially by a DOEd Fellowship

PUBLICATIONS

- "Galactic HI and the Interstellar Medium in Ursa Major," Jahoda, K., Lockman, F. J., and McCammon, D. 1990, Ap. J., 354, 184.
- "A Model for the Distribution of Material Generating the Soft X-ray Background," Snowden, S. L., Cox, D. P., McCammon, D., and Sanders, W. T. 1990, Ap. J., 354, 211.
- "Galactic Hydrostatic Equilibrium with Magnetic Tension and Cosmic Ray Diffusion," Boulares, A., and Cox, D. P. 1990, Ap. J., 365, 544.
- "The Soft X-ray Background and its Origins," McCammon, D., and Sanders, W. T. 1990, in Annual Reviews of Astronomy and Astrophysics, ed. G. Burbidge (Palo Alto: Annual Reviews, Inc.), Volume 28, 657.
(Invited review paper.)
- "Limits on the Density of Neutral Gas within 100 Parsecs from Observations of the Soft X-ray Background", Juda, M., Bloch, J. J., Edwards, B. C., McCammon, D., Sanders, W. T., Snowden, S. L., and Zhang, J. 1990, Ap. J., 367, in press.
- "Efficiency of Short Heat Exchangers for Helium Vapor Cooling," Steffensrud, D., Bahls, J., Christenson, E., Fassnacht, K., Guckel, E., Harriman, D., Nahn, S., Vu, P., and Zhang, J. 1990, Rev. Sci. Instr., 62, in press.
- "The First Soft X-ray Image of the Moon," Schmitt, J. H. M. M., Snowden, S. L., Aschenbach, B., Hasinger, G., Pfeffermann, E., Pradehl, P., and Truemper, J. 1990, Nature, submitted.

CONFERENCE PROCEEDINGS

- "Observing Soft X-ray Line Emission from the Interstellar Medium with X-ray Calorimeters on a Sounding Rocket," Zhang, J., Edwards, B., Juda, M., Kelley, R., Madejski, G., McCammon, D., Skinner, M., Schoelkopf, R., and Szymkowiak, A. 1990, in High Resolution X-ray Spectroscopy of Cosmic Plasmas, Proceedings of IAU Symposium No. 115 (Cambridge, MA, 22 - 25 Aug 1988), eds. Gorenstein, P. and Zombeck, M. (Cambridge: University Press), p. 361.
- "The SHEAL Diffuse X-ray Spectrometer Experiment," Sanders, W. T., Snowden, S. L., and Edgar, R. J. 1990, in High Resolution X-ray Spectroscopy of Cosmic Plasmas, Proceedings of IAU Symposium No. 115 (Cambridge, MA, 22 - 25 Aug 1988), eds. Gorenstein, P. and Zombeck, M. (Cambridge: University Press), p. 376.
- "Extreme Ultraviolet Properties of Cooling Bubbles of Hot Gas in the Interstellar Medium," Cox, D. P., and Slavin, J. 1990, in Extreme Ultraviolet Astronomy: A Selection of Papers Presented at the First Berkeley Colloquium on Extreme Ultraviolet Astronomy (University of California, Berkeley, 19-20 January 1989), eds. Malina, R. F., and Bowyer, S. (Elmsford, NY: Pergammon) in press.
- "Galactic Background Radiation in the 78 to 111 eV Band," Sanders, W. T., Bloch, J. J., Edwards, B. C., Jahoda, K., Juda, M., McCammon, D., and Snowden, S. L. 1990, in The Galactic and Extragalactic Background Radiation, Proceedings of IAU Symposium No. 139 (Heidelberg, 12-16 June 1989), eds. Bowyer, S., and Leinert, C. (Dordrecht: Kluwer), p. 241.

- "The Diffuse Interstellar Medium," Cox, D. P. 1990, in The Interstellar Medium in Galaxies (2nd Wyoming Conference on the Interstellar Medium, Grand Tetons, WY, July 1989), eds. Thronson, H. A., Jr., and Shull, J. M. (Dordrecht: Kluwer), p. 181.
- "Thermal Detection of X-rays," McCammon, D., Edwards, B., Juda, M., Plucinsky, P., Zhang, J., Kelley, R., Holt, S., Madejski, G., Moseley, S. H., and Szymkowiak, A. 1990, in Low Temperature Detectors for Neutrinos and Dark Matter III (Gran Sasso, L'Aquila, Italy, 20-23 September 1989), eds. Brogiato, L., Camin, D. V., and Fiorini, E. (Gif sur Yvette: edition Frontieres), p. 213.
- "The ROSAT Diffuse X-ray Background Survey," Snowden, S. L., and Schmitt, J. H. M. M. 1990, Astrophys. & Space Science, 171, 207. (Proceedings of the 11th European Regional Astronomical Meeting of the IAU, Tenerife, 1989.)
- "Characteristics of the Diffuse Interstellar Medium," Cox, D. P. 1990, in Fragmentation of Molecular Clouds and Star Formation: Proceedings of IAU Symposium No. 147 (Grenoble, 12-16 June 1990), eds. Falgarone, E., Boulanger, F., and Duvert, G. (Dordrecht: Kluwer), in press.
- "Hot Gas in the Disk, Halo, and Disk-Halo Interaction," Cox, D. P. 1990, in The Interstellar Disk-Halo Connection in Galaxies, Proceedings of IAU Symposium No. 144 (Leiden, June 18-22 1990), ed. Bloemen, H. (Dordrecht: Kluwer), in press.
- "Cryogenic Microcalorimeters for High Resolution Spectroscopy: Current Status and Future Prospects", McCammon, D., Cui, W., Juda, M., Plucinsky, P., Zhang, J., Kelley, R. L., Holt, S. S., Madejski, G. M.,

Moseley, S. H., and Szymkowiak, A. E. 1990, Nuclear Physics A527, in press (M.I.T., 25-29 June 1990).

CONTRIBUTED TALKS

"Possible Absorption of the Diffuse X-ray Background by a Nearby Interstellar Cloud," Edwards, B. E., Juda, M., McCammon, D., Plucinsky, P., Sanders, W., and Zhang, J. 1990, 175th Meeting of the AAS, Washington, D.C., January 1990.

"X-ray Quantum Calorimeter (XQC): A Sounding Rocket Instrument for High Spectral Resolution Studies of the ISM," Juda, M., Cui, W., McCammon, D., Plucinsky, P., Snedeker, C., Zhang, J., Kelley, R., Madejski, G., Moseley, H., Szymkowiak, A. 1990, 176th Meeting of the AAS, Albuquerque, New Mexico, 10-14 June 1990.

COLLOQUIA AND SEMINARS

"Current Status of our Understanding of the Diffuse Interstellar Medium," D. P. Cox, Service d' Astrophysique, Saclay, France, October 1990.
"The Diffuse Interstellar Medium", D. P. Cox, Institut d' Astrophysique, Paris, France, November 1990.

PUBLIC SERVICE LECTURES

"The Diffuse Interstellar Medium, Revisited", D. P. Cox, Madison Area Amateur Astronomers, March 1990.

"X-ray Astronomy," D. McCammon, Wisconsin State Science Symposium
presentation (program for high school students) 1 March 1990, Madison.
D. McCammon, Presentations for Wisconsin Minority Undergraduate Recruitment
Project, Campus Visitation Program; 15 & 16 November 1990.

Ph.D. THESES

Brad Edwards	March 1990	"Possible Absorption of the Diffuse X-ray Background by a Nearby Interstellar Cloud"
Jonathan Slavin	June 1990	"Diffuse Gas in the Interstellar Medium: Studies Involving Coupled Ionization, Radiation, and Dynamics"