SPECTRAL OBSERVATION OF THE SOFT X-RAY BACKGROUND AND OF THE NORTH POLAR SPUR WITH SOLID STATE SPECTROMETERS

R. Rocchia, M. Arnaud, C. Blondel, C. Cheron, J.C. Christy
L. Koch and R. Rothenflug
Section d'Astrophysique, Centre d'Etudes Nucléaires de Saclay, France

H.W. Schnopper and J.P. Delvaille
Harvard/Smithsonian Center for Astrophysics
Cambridge, Massachusetts, USA

In this paper, we present preliminary results of soft X-ray diffuse background observations. We observed two particular regions of the sky in the 0.3-1.5 keV range. The detection system consisted of three independent, 1 cm diameter, cooled solid state detectors. Nearly overlapping fields of view subtended a solid angle of approximately 1/4 sr. Except for the field of view, the whole set was similar to that described in Schnopper et al. (1982) (hereafter referred to as paper 1). This system was flown on board a three-axis stalibized rocket. The flight took place at White Sands Missile Range on 1981 May 4 at 0755 UT.

The first target ($\ell^{II} \sim 120°$, $b^{II} \sim 70°$) is a region of the sky close to the North galactic pole. We consider its spectrum as representative of the soft X-ray foreground produced by the local hot bubble. 155 seconds of useful data were obtained. The second target ($\ell^{II} \sim 25°$, $b^{II} \sim 25°$) is the brightest region linked with the North Polar Spur (Iwan 1980) and was observed for 170 seconds. Only data above 400 eV are presented in this preliminary report, a careful analysis of the noise made sure that no contamination occurs above this energy.

1. THE SOFT X-RAY FOREGROUND SPECTRUM

The chosen region of the sky lies more than 30° away from the radio ridge of the North Polar Spur (NPS) (Berkhuijsen et al. 1971) and it is among the brightest regions of the sky in the B-band and the C-band maps of the Wisconsin group (see for instance Mc Cammon 1979).

The contribution of the high energy X-ray background was subtracted using the spectrum $11.E^{-1.4}\ \exp(-\sigma(E).N_H)$. The column density $N_H = 3.10^{20}$ H atoms/cm^2 includes neutral atomic hydrogen on the line of sight (Daltabuit and Meyer 1972) and a probable contribution of molecular hydrogen (see paper 1). Our results are, however, not very sensitive to this parameter.

After this subtraction, we obtained the residual spectrum plotted on figure 1. It is now largely proved that this emission has a thermal origin (Inoue et al. 1979, Schnopper et al. 1982). The feature around 530 eV is attributed to the emission of O VII ions. We compared these data with a model of plasma X-ray emission developped at Saclay which includes the atomic data of Kato (1976). (See

J. Danziger and P. Gorenstein (eds.), Supernova Remnants and their X-Ray Emission, 357–360.

paper 1). Runs were performed with local galactic abundances (Meyer 1979) and with an absorption of 6.10^{19} H atoms/cm of intervening material (Inoue et al. 1979).

The first test was made with a single-temperature model with line emission. We get a chi-square of 37 for 22 degrees of freedom, but the fit is not good above 800 eV. But by adding a second component we succeed to lower the chi-square to about 18. However, the poor statistics of this experiment does not allow a definite conclusion about the spectrum shape of this second component (line spectrum or pure bremsstrahlung). We displayed on figure 1, as an example, the curve obtained from two line emission spectra. The absorbing material for the second component was arbitrarily fixed to the same value used for the first. The temperature ranges are, at the 90% confidence level :

$$T_1 = 8.7 \, {}^{+2.1}_{-2} \, . \, 10^{50} \, K \qquad T_2 = 5.6 \, {}^{+6}_{-3} \, . \, 10^6 \, °K$$

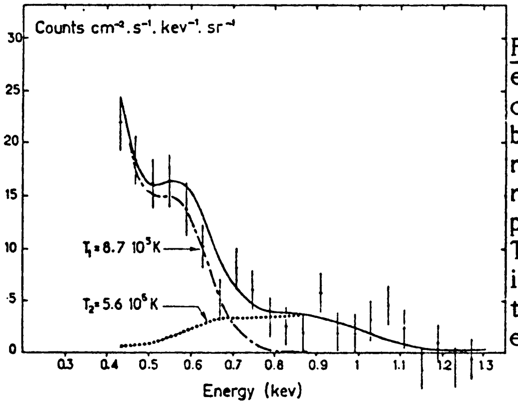

Fig.1. Spectrum of the foreground emission. The experimental points are compared with the convolution of the best fit model and the detector response. The vertical error bars represent $\pm$ 1 σ on each experimental point.
The contribution of each component is shown in the case of the two-temperature model (with line emission).

These results confirm the temperature value of the soft X-ray foreground measured during the first flight (Rocchia et al. 1981). The existence of a second component in the soft X-ray background was extensively discussed in Nousek et al. (1982) : our results seem to show that it does exist, at least in this particular direction. We checked that the contribution of point X-ray sources is negligible, and we are left with the possibility that this component is due to the Galactic Halo.

2. THE NORTH POLAR SPUR SPECTRUM

The NPS is a prominent feature in surveys of the soft X-ray background in the energy range 0.5-1 keV (see for instance, Hayakawa et al. (1977) and Burstein et al. (1977). The region centered on ($\ell^{II} \sim 25°$, $b^{II} \sim 25°$) appears as the brightest region associated with this old supernova remnant (Iwan 1980, Davelaar et al. 1980).

The contribution of the extragalactic background was subtracted with the same spectrum as above, but with a total column density of 7.10^{20} H atoms/cm for the intervening material. The residual spectrum is plotted on figure 2. This emission includes contributions from the NPS itself and of course the soft X-ray

https://doi.org/10.1017/S0074180900034112 Published online by Cambridge University Press

foreground. It seems more complex that the previous spectrum, with Fe XVII, Ne IX and O VIII line contributions. A slight enhancement can be seen around 1350 eV at the energy of the Mg XI lines.

As a first test, a two-temperature model was tried with the following parameters :

a) local galactic abundances
b) an intervening material of 6.10^{19} H atoms/cm^2 for the lower temperature as above
c) a column density of 7.10^{20} H atoms/cm^2 for the higher temperature assuming all the absorbing material lies between the local hot bubble and the NPS.

On figure 2, the best fit curve is compared with the experimental points. The contribution of the two temperatures, with the following best fit values, are also plotted :

$T_1 = 1.10^6$ K E.M. = 6.7 10^{-2} cm^{-6} pc

$T_2 = 4.7\ 10^6$ K E.M. = 1.25 10^{-2} cm^{-6} pc

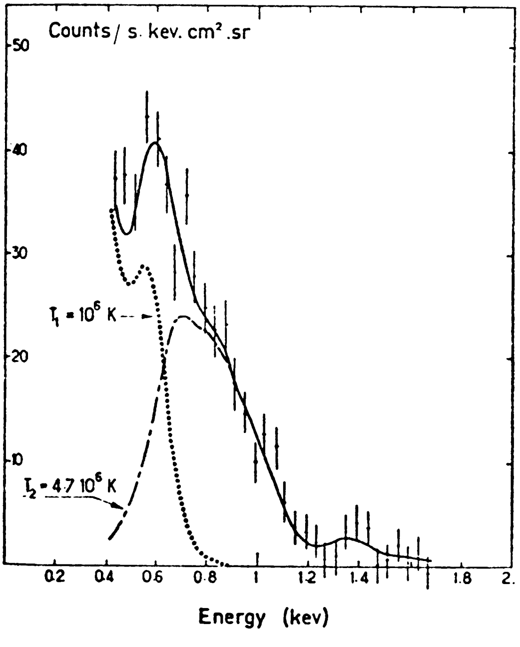

Fig.2. Spectrum obtained in the direction of the brightest region in the North Polar Spur ($\ell^{II} \sim 25°$, $b^{II} \sim 25°$). In addition to the total best fit spectrum, the contributions of the two components are plotted separately. Local galactic abundances are assumed for both components.

We get a chi-square of 33 for 32 d.o.f. in the case of this best fit. The two contours at 90% and 68% confidence levels are given on figure 3 for this two-temperature model.

This sharing in two temperatures is somewhat arbitrary, since part of the low temperature emission is probably due to the NPS (Iwan 1980). The high emission measure we obtained for the low temperature can be an indication of the existence of this contribution.

In a future paper, we will try to compare these data with previous results on the NPS.

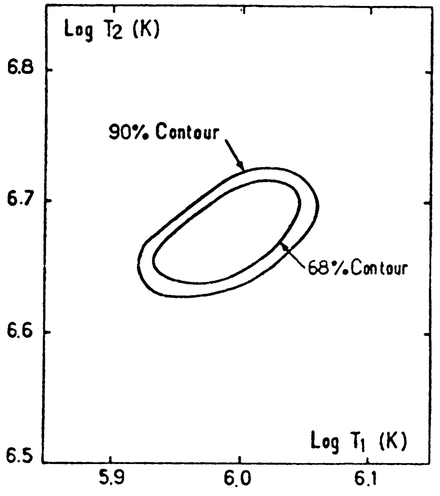

Fig. 3. Contours at 90% and 68% confidence levels obtained by fitting the data depicted on fig.2 with a two-temperature model.

Acknowledgements. This program is supported in part by NASA (USA) Grant 5304 and by CNES and CEA (France). We thank J. Gomes and J. Jenkins of SAO and the GERES staff of Saclay for their engineering and technical assistance. We thank O. Testard for the cryogenics. We also thank the Sounding Rocket Division staff at GSFC and WSMR and the staff at LURE, Orsay, for their assistance and hospitality. We thank Mr Friant for the detectors.

REFERENCES

Berkhuijsen, E.M., Haslam, C.G.T., Salter, C.J. 1971, A. and A. 14, 252.
Davelaar, J., Bleeker, J.A.M. 1980, A. and A. 92, 231.
Inoue, H., Koyama, K., Matsuoka, M., Ohashi, T., Tanaka, Y., Tsunemi 1979, Ap.J.Lett., 227, L85.
Inoue, H., Koyama, K., Matsuoka, M., Ohashi, T., Tanaka, Y., and Tsunemi, H. 1980, Ap.J. 238, 886.
Iwan, D. 1980, Ap.J. 239, 316.
Kato, T. 1976, Ap.J. suppl. 30, 397.
Meyer, J.P. 1979, in "Les Eléments et leurs Isotopes dans l'Univers", 22nd Liège International Astrophysical Symposium (Univ. of Liège Press), p. 153, 465, 477, 489.
Nousek, J.A., Fried, P.M., Sanders, W.T., Kraushaar, W.L. 1982, Ap.J. 258, 83.
Rocchia, R., Arnaud, M., Blondel, C., Cheron, C., Christy, J.C., Ducros, R., Koch, L., Rothenflug,R., Schnopper, H.W., and Delvaille, J.P. 1981, Space Sci. Rev. 30, 253.
Schnopper, H.W., Delvaille, J.P., Rocchia, R., Blondel, C., Cheron, C., Christy, J.C., Ducros, R., Koch, L., Rothenflug, R. 1982, Ap.J. 253, 131.