PRIMEVAL CLUSTERS OF GALAXIES AND THE X-RAY BACKGROUND

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The X-ray telescope for HEAO-B, due for launch next year, will extend our observing power in X-ray astronomy by a very large factor. For example, its sensitivity to point sources will be 10^3 greater than the limit of existing X-ray sky surveys. Even more intriguing will be its capability to image the all-sky X-ray background radiation on an arc minute or sub arc minute scale. The origin of this background is still a mystery. The simplest hypothesis, that it is the integral of radiation from the more distant members of the classes of discrete X-ray sources such as clusters of galaxies, Seyferts, QSO's and other active galaxies, can only explain part of the background.

The investigation I report here begins an attempt to explain the origin of the X-ray sources in clusters of galaxies as due to primeval gas clouds associated with density perturbations in the early universe. The clouds become the sites for formation of clusters of galaxies. Sufficient heating of the gas in the protocluster occurs to prevent further collapse, but not enough to cause evaporation of the gas away from the cluster. I call this maximal heating. The temperature is related to the size and mass of the protocluster. One result is the prediction that there were more protocluster X-ray sources at $z \sim 1$ than there are now. These are the primeval gas clouds that were maximally heated but had a high enough density so their bremsstrahlung cooling times were short compared with their present age. Therefore, they are not now X-ray sources, but the larger, less dense clouds as in the Coma cluster have not cooled significantly and are still luminous in X-rays.

I have applied this model to predict the appearance of the X-ray sky on a scale of ~ 10 arc minutes in the HEAO-B telescope. Free parameters are: q_o, density perturbation spectrum at the point of separation, range of cloud sizes, epoch at which heating begins, and total space density of maximally heated clouds.

Preliminary conclusions are: 1) such primeval gas clouds are observable, 2) angular sizes of the clouds can be measured from $\sim 10''$ to $\sim 10'$, and 3) it should be possible to analyze the distribution of angular sizes and apparent brightnesses to test the model and perhaps to obtain information on q_o, z_o and the density perturbation spectrum in the early universe.

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DISCUSSION

Ozernoy: How does the X-ray luminosity per cluster within the supercluster X-ray sources compare with that of cluster sources such as Coma?

Kellogg: My rough estimates suggest there is not much difference.

Zeldovich: Can HEAO-B distinguish between power-law and bremsstrahlung spectra of such weak sources as a distant protocluster of galaxies?

Kellogg: The HEAO-B observatory is equipped with four spectrophotometers: a monitor proportional counter of $\sim 10^3$ cm^2 and 1^o field of view and three others. The objective grating spectrometer disperses the image of an X-ray source in the focal plane to give a resolution of $\lambda/\delta\lambda \sim (\lambda/4Å) \times 40$. Its efficiency is $\sim$ 10% in first order. The solid state spectrometer has $E/\delta E \sim 10$ and 100% efficiency above 1 keV. The focal plane crystal spectrometer can provide $\lambda/\delta\lambda$ up to 10^3 at much lower efficiency. Both the grating and the solid state spectrometers should be capable of detecting iron lines in cluster sources at z = 1-2. It will be more difficult to obtain an accurate measurement of the shape of the continuum for these sources, due to the background counts in the monitor counter.

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