Interstellar dust

Another important aspect is the measurement of X-ray halos which surround point sources because of scattering on interstellar dust grains. Similar observations to those performed on bright sources by previous instruments can be carried out with improved sensitivity using ROSAT because of the large collecting power and the extremely low microroughness (3.5 Å RMS) of the mirror system. First results [5] show that the grain size distribution in the range 0.04-0.4 µm is measured much more accurately.

Galaxies, Clusters of Galaxis and Quasars

It is well known that galaxies are not distributed randomly in space but show distinct clustering effects. Clusters of galaxies are strong X-ray emitters and their radiation comes from a hot plasma produced by galaxy-galaxy collisions. While not too much happens to the stars in such events, it would appear that the interstellar media of the colliding galaxies are shock heated and swept out into intergalactic space.

Estimates show that the total number of clusters of galaxies expected to be found in the ROSAT survey is 4000-6000 — many more than have been identified up to now using X-rays [Böhringer H., private communication]. Optical spectroscopic redshift measurements are scheduled and these will permit measurements of the cluster distribution out to redshifts z of 0.3 or more — much further than by simply observing the distribution of galaxies ($z < 0.1$). We note also that generally well-know large scale structures such as the "Great Wall" and the "Great Attractor" are both within the reach of ROSAT's spectroscopic capabilities.

Clusters grow by merging

The main unanswered question concerning the distribution of space objects is how the initially homogeneous Universe evolved into the present highly structured state containing galaxies, clusters and superclusters. While the analysis of the large ROSAT samples will take some time, clues to the evolution of individual clusters of galaxies can be found by studying their morphology.

As a matter of fact, the ROSAT observations show that a number of bright clusters contain more internal structure than previously thought. For instance, in Abell 2256 one sees (Fig. 6) a clear double peak distribution suggesting the infall of a smaller cluster into a larger one [6]. Furthermore, the well-known Coma and Perseus clusters exhibit interesting sub-structures. It appears that one is seeing here some indications of how clusters grow, namely by "merging" or the infall of small groups of galaxies.

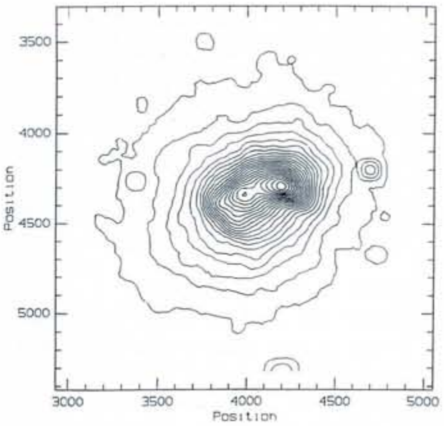

Fig. 6 — A ROSAT image of the Abell 2256 galaxy cluster reveals a clear double peak structure indicating the merging of two clusters.

Feeding active galactic nuclei or reprocessing

Quasars and other active galactic nuclei (AGN), which represent the largest class of ROSAT survey sources (numbering about 20000), are found at even larger distances and redshifts. The few hundred of these sources which have been identified so far show redshifts of up to $z = 3.8$. The ROSAT data confirm that the power law spectra of these objects generally steepens towards low energies, strongly reinforcing the evidence that these soft "X-ray excesses" and the UV excesses ("UV bumps") in AGN spectra have the same origin, *i.e.*, they both result from a broad maximum in the XUV whose main part is obscured by interstellar photoelectric absorption. This XUV bump could be due to either emission from an accreting disk feeding a central supermassive black hole or to reprocessing.

The galactic background: a decreasing quasar density and a supercluster

The nature of the extragalatic X-ray background is still unresolved 29 years after its discovery. Is it made up from the superposition of mainly faint sources, or is it partly due to truly diffuse emission from intergalactic space? One needs to perform very deep observations to answer these questions. The longest ROSAT telescope pointing extends to flux levels almost a factor of 10 smaller than those of the Einstein Observatory: about 45 % of the total extragalactic flux can be resolved into point sources [Hasinger G. *et al.*, in preparation] which are mainly quasars at large redshifts [7]. In the deepest ROSAT field, the density of objects is 200 per square degree, *i.e.*, more than the quasar density found in deep optical fields [Hasinger G. *et al.*, in preparation].

The number - flux relationship (log N - log S) at these weak fluxes shows a clear flattening, indicating that the space density of X-ray emitting quasars decreases beyond a redshift of $z = 2$. Also of great interest is the discovery of some patchy structures in the diffuse sky background near the North Ecliptic Pole [8]. Optical observations show that these structures are due to a supercluster — the first to be discovered by X-ray observations [Burg R. *et al.*, *Nature*, submitted].

All-in-all, it is evident that ROSAT will tell us much more about the large scale distribution of matter in our Universe.

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Complementary EC Rôle

A Communication by the Commission of the European Community (CEC) to the EC Council and Parliament in 1998 sought to develop a systematic approach to EC space activities. For science, there resulted a series of initiatives such as an opening up of EC programmes to microgravity experiments from 1990, studies of earth observation systems, and the development of a working relationship with ESA *via* joint working groups.

Technical and political changes called for a fresh appraisal so Roy Gibson, ESA's former Director-General who heads a task force to set up the EC's European Environmental Agency, led a review of EC space activities by an expert panel. The panel's report *The European Community: Crossroads in Space* published in October called for a long-term strategy with the environment as a priority in order to intensify involvement in space-related areas. Such a strategy may emerge once an EC Parliament report updating the 1987 Toksvig Report, a second CEC Communication due in March 1992 and the results of CEC internal studies are presented.

In seeking a truly collaborative European space policy of maximum benefit building on some impressive recent achievements, the panel felt long-term EC goals should be to foster: a competitive space industry; an independent launch capability; a framework for exploiting space technology especially in telecommunications and earth observation; basic knowledge and further technologies essential for a vigorous space effort; and international collaboration. Space science was seen as a "pathfinder" with wide implications and challenging but stimulating technical requirements, so it is essential to study the Earth and the Universe in a complementary way to ESA and large multinational programmes. Space science should not be "put into a cupboard" and space scientists ought to be further encouraged to turn to EC programmes for support.