PHYSICS OF GALAXY CLUSTERS AND HOW IT AFFECTS COSMOLOGICAL TESTS

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We have worked on the analysis of the Chandra observations of the nearby and distant clusters of galaxies, and on the expansion of the sample of distant X-ray clusters based on the archival ROSAT PSPC data. Some of the scientific results are discussed below.

1) Heat conduction in the intergalactic medium of the Coma cluster.

The Chandra image of the central region of the Coma cluster reveals that both its dominant galaxies, NGC 4874 and NGC 4889, retain the central parts of their X-ray gas coronae. The interstellar gas with a temperature of 1--2 keV is confined by the hot intergalactic medium of the Coma cluster into compact clouds (only 3 kpc in radius) containing 10^8 Solar masses of gas. The physical state of the gas in these clouds appears to be determined by a delicate balance between radiative cooling and suppressed (by a factor of 30--100) heat conduction through the interface between these clouds and the hot cluster gas.

The paper presenting these results has been published in ApJ (2001, ApJ, 555, L87)

2) Distant X-ray clusters

We have continued a program of optical follow-up observations of the distant X-ray selected clusters of galaxies found in the ROSAT PSPC images. The goal of this program is to confirm X-ray detections and to measure the cluster redshifts. We have imaged 67 out of about 250 new galaxy clusters, and measured redshifts for 15, although we were particularly unfortunate to lose a large portion of the allocated observing time to weather. Upon completion of observations for the entire cluster sample, the optical imaging data will be used for the photometric redshift estimates and for planning the spectroscopic observations.

We have also analyzed the data from Chandra and XMM observations of several interesting objects from our sample.

a) Chandra observations of X-ray Overluminous Elliptical Galaxies

We have observed with Chandra two apparently isolated elliptical galaxies with cluster-like halos of X-ray gas and dark matter. Due to the relaxed morphology, these objects are ideal for the mass measurements and study of the matter inventory.

Chandra data provide accurate gas temperatures almost to a virial radius, and thus allow a measurement of the total mass in the system via the hydrostatic equilibrium equation. The mass of baryons in the intergalactic medium can be derived easily from the same X-ray data, while the mass of baryons in stars was obtained from the optical observations on the Nordic Optical Telescope. The main conclusion from our analysis can be formulated as follows: baryons make up 13+-3% o f the total mass in the system; if this fraction is representative for that in the Universe, the cosmological density parameter is 0.6+-0.15.

These results were presented at the conferences "Lighthouses in the Universe" and the Ringberg Castle workshop "Galaxy Clusters as CMB Foregrounds", and the paper for ApJ is in preparation.

b) XMM observation of an identified extended X-ray source

For several extended X-ray sources detected by ROSAT, we have failed to detect optical galaxies even in the very deep exposures. An exciting possibility is that these sources are very distant clusters at redshift z>1, so that the galaxy light is redshifted to the infrared. To test this possibility, we have observed the brightest of the unidentified extended sources with XMM. The XMM snapshot showed that there is a compact group of 6 point-like X-ray sources; due to poorer angular resolution of the ROSAT PSPC they we confused into a single extended object. Only one of the XMM sources can be identified with an optical object. The nature of these sources in under the investigation.