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Deep ROSAT-HRI Observation of the cD Galaxy NGC 1399 in the Fornax Cluster: Morphology and Dynamical Status of the X-Ray Halo

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Abstract. We present the results of a deep (167 ks) observation of the NGC 1399/NGC 1404 field obtained from data collected between 1993 and 1996 with the ROSAT High Resolution Imager. We take advantage of the 5" resolution of the HRI to study in detail the structure of the galactic halo and to relate the results to those obtained at larger scales with poorer resolution instruments. We discuss possible non-equilibrium scenarios that may explain the global halo structure. We also find evidence of interactions between the nuclear radio source and the inner gaseous halo.

The study of galactic and cluster gaseous halos has often been based on the assumption of homogeneity and spherical symmetry. We have analyzed a deep ROSAT HRI observation centered on the dominant Fornax cluster galaxy NGC 1399, along with the archival ROSAT PSPC data of the same field. The HRI/PSPC image of the NGC 1399 halo shows significant departures from the above simplified assumptions.

We found an extended and asymmetric halo extending on cluster scales ($r >$ 90 kpc). The HRI image revealed the existence of significant ($> 3\sigma$) filamentary structures and cavities in the galactic halo, due to density fluctuations in the hot gas (Fig.1, left panel).

The halo profile is not consistent with a simple Beta model but suggests the presence of three different components. The combined HRI and PSPC data were fitted with a multi-component bidimensional model, consisting of: (1) a 'central' component (dominating for $r <$ 50") centered on the optical galaxy and whose distribution follows the luminous matter profile, (2) a 'galactic' component (50" $< r \leq$ 400") displaced $1'$ (5.5 kpc) South-West of NGC 1399 and (3) a 'cluster' ellipsoidal component ($r >$ 400") centered $\sim 5.6'$ (31 kpc) North-East of the galaxy. The cooling times of the central and galactic components are smaller than the Hubble time, suggesting the presence of a central cooling flow.

The binding mass estimates, obtained assuming hydrostatic equilibrium, revealed that the dynamics of the central region are dominated by stellar matter while, at radii larger than 2 arcmin, the gravitating mass exceeds the stellar

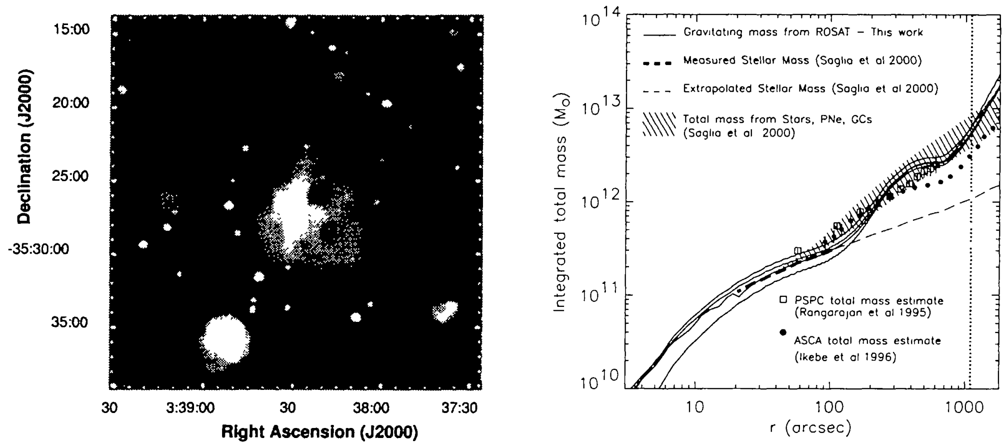

Figure 1. **Left:** Adaptively smoothed X-ray image of NGC 1399 (central peak) and NGC 1404 (SW peak). In the case of NGC 1399 the X-ray emission extends further out than the optical galaxy and reveals the presence filamentary structures and voids. **Right:** Integrated gravitating mass for 4 different temperature profiles (continuous lines). Open squares and filled circles represent previous X-ray determinations. The gravitating mass range derived from optical observations of stars, GCs and PNe, is shown as a shaded region. The contribution of the stellar matter is represented by the dashed lines.

one (Fig.1, right panel). The large scale surface brightness distribution can be explained if the galaxy hosts a large dark halo with different dark matter distributions on galactic and cluster scales. Alternative models that explain the GCs abundance and optical velocity dispersion profiles through tidal interactions with Fornax cluster galaxies are compatible with our data only if such encounters produce a significative flattening of the outer gas distribution. Tidal interactions may also explain the presence of the density fluctuations in the galactic halo.

Ram pressure from the cluster halo is able to account for the decentering of the optical galaxy with respect to the galactic X-ray component if NGC 1399 is moving subsonically (10-100 km s^{-1}) in the cluster potential. Instead, the displacement of the center of the cluster component with respect to the nearest Fornax galaxies may suggest that the cluster is not relaxed and may be undergoing a merger event with a nearby subgroup.

We do not detect the X-ray counterpart of the nuclear radio source and pose an upper limit of $L_X^{3\sigma} = 3.9 \times 10^{39}$ erg s^{-1} on its luminosity in the 0.1-2.4 keV band. Our data also support thermal confinement of the radio emitting plasma. We found X-ray emission enhancements aligned with the radio jets that may be due to shocked gas and X-ray 'holes' and enhancements coincident with the position of the radio lobes. The latter are consistent with a scenario in which the hot gas is displaced by the radio plasma pressure. Alternative models of Inverse Compton scattering of CMB photons fail to account for the observed excesses.

A full discussion of these results can be found in Paolillo et al.(2001, in press in ApJ).