Cosmological Implications from an X-Ray Flux-Limited Sample of Galaxy Clusters

Thomas H. Reiprich, Hans Böhringer & Peter Schuecker

Max-Planck-Institut für extraterrestrische Physik, 85748 Garching, Germany
Email: reiprich@mpe.mpg.de

Abstract: Galaxy clusters are the most massive collapsed objects in the Universe. Tight constraints on cosmological models can be obtained from comparisons of measured and simulated or analytical cluster mass functions. In this work the X-ray brightest galaxy clusters in the sky – excluding the galactic band – are compiled based on surveys exploiting the ROSAT All-Sky Survey. The gravitational mass function is determined and compared to previous determinations (Fig. 1), where large deviations are found depending mainly on the definition of the cluster outer boundary. The observational mass function is further compared to a simple analytical mass function based on the Press-Schechter mass function (Fig. 3). It is found that the combination of parameter values $0.1 < \Omega_0 < 0.4$ and $0.7 < \sigma_8 < 0.9$ represents the data well. Integrating all individual mass densities (Fig. 2) shows further that only a few percent of the total mass in the Universe is bound in galaxy clusters with masses larger than $3.5 \times 10^{13}\, h_{50}^{-1}\,\mathrm{M}_\odot$.

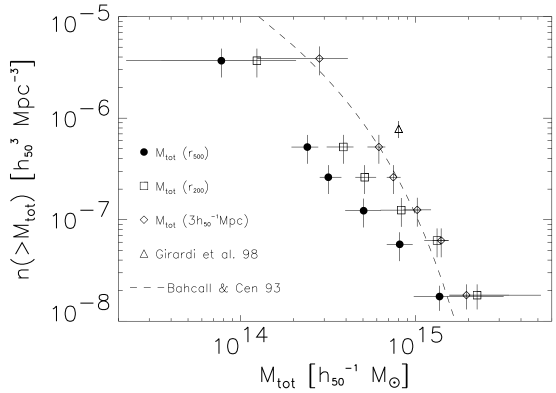

Fig. 1. Observational cumulative mass function derived for different outer radii from the HIghest X-ray FLUx Galaxy Cluster Sample (*HIFLUGCS*, Reiprich & Böhringer 1999) compared to the mass functions by Bahcall & Cen (1993) and Girardi et al. (1998). The *HIFLUGCS* mass function derived for masses determined at overdensities of 500 ($M_{\mathrm{tot}}(r_{500})$) differs by up to a factor of 10 from the mass function for a fixed radius of $3\,h_{50}^{-1}\,\mathrm{Mpc}$.

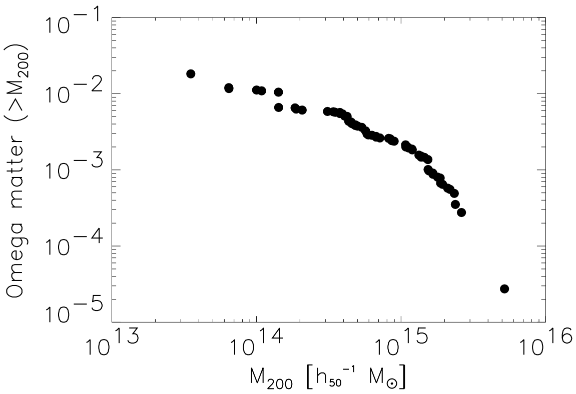

Fig. 2. Cumulative distribution of cluster mass densities for *HIFLUGCS* normalized by the critical density. It is seen that only $\sim 2\%$ of the total mass in the Universe is bound in galaxy clusters with masses larger than $3.5 \times 10^{13}\, h_{50}^{-1}\,\mathrm{M}_\odot$ for $\Omega_0 = 1$ ($\sim 6\%$ for $\Omega_0 = 0.3$). This means that most of the mass must reside in smaller systems like galaxies, ever larger systems like superclusters or is hidden somewhere.

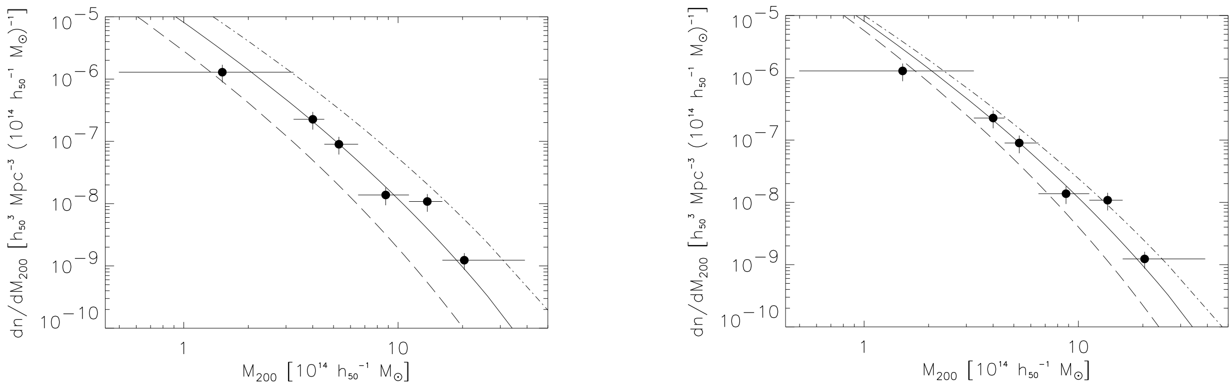

Fig. 3. Observational differential mass function compared to a simple analytical mass function based on the Press-Schechter formalism (PS, Press & Schechter 1974). For the comparison we choose the observational mass function for $M_{\mathrm{tot}}(r_{200})$ because this mass should most closely resemble the virial cluster mass assumed in the PS approach. A power law power spectrum has been assumed with slope $n = -1.8$ and a collapse overdensity $\delta_c = 1.69$ is used. On the left the amplitude of the initial density fluctuations is fixed at $\sigma_8 = 0.8$ and the density parameter is varied $\Omega_0 = 0.1, 0.2, 0.4$. On the right $\Omega_0 = 0.2$ and $\sigma_8 = 0.7, 0.8, 0.9$. The values are consistent with an OCDM Universe and describe the data well.

References:

Bahcall, N. A. & Cen, R. 1993, ApJ, 407, L49
Girardi, M. et al. 1998, ApJ, 506, 45
Press, W. H. & Schechter, P., 1974, ApJ, 187, 425
Reiprich, T. H. & Böhringer, H., 1999, Proc. 19th Texas Symposium, Paris

Further information on *HIFLUGCS* can be retrieved from: http://www.xray.mpe.mpg.de/∼reiprich/