Relating Galaxy Cluster X-Ray Luminosities to Gravitational Masses in Wide Angle Surveys

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The cosmologically most important cluster parameter is its mass ($M_{\rm grav}$). For this reason in large cluster surveys it is aimed to select clusters based on $M_{\rm grav}$. Here it is shown that cluster surveys selecting clusters by X-ray luminosity ($L_{\rm X}$) effectively select by $M_{\rm grav}$ (Fig. 2). A frequently used approach in X-ray cluster surveys to relate $L_{\rm X}$ to $M_{\rm grav}$ involves three components: Converting $L_{\rm X}$ to the intracluster gas temperature ($T_{\rm gas}$) using an *observational* $L_{\rm X} - T_{\rm gas}$ relation. Converting $T_{\rm gas}$ to $M_{\rm grav}$ using an $T_{\rm gas} - M_{\rm grav}$ relation where the slope is assumed from simple *theoretical* scaling relations and the normalisation is taken from *numerical* simulations. Here it is proposed to directly use the empirical $L_{\rm X} - M_{\rm grav}$ relation (Fig. 3).

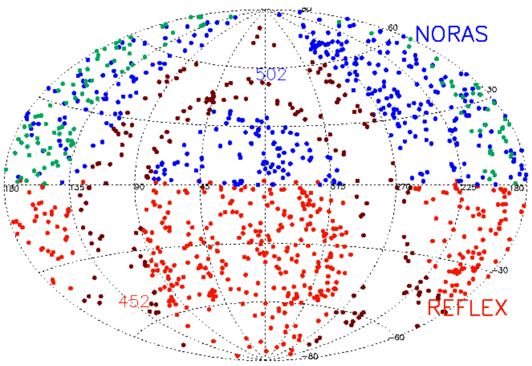

Fig. 1: Distribution of ~1000 galaxy clusters in equatorial coordinates found in three surveys based on the ROSAT All-Sky survey: REFLEX, NORAS and GPS (Böhringer et al. 2000a,b,c). For these clusters the empirical $L_{\rm X} - M_{\rm grav}$ relation (Fig. 3) is used to map the peaks of the large scale mass distribution and to constrain the cluster power spectrum on scales up to 1000 h_{50}^{-1} Mpc (Schuecker et al. 2000).

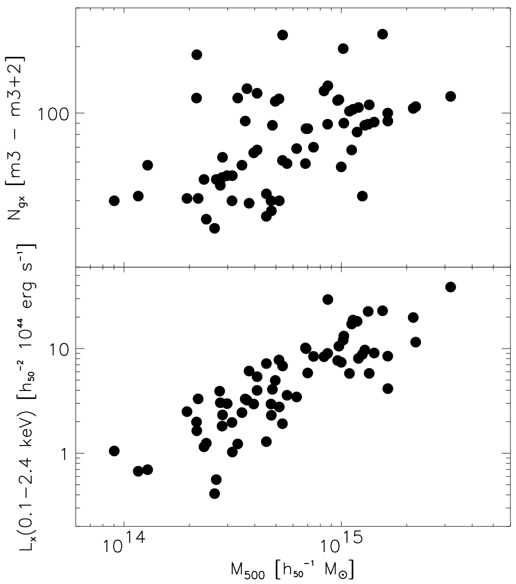

Fig. 2. One frequently used approach in optical cluster surveys has been to select clusters by their richness, simply speaking by the number of apparent cluster galaxies ($N_{\rm gx}$). On the X-ray side it has been shown that there exists a good correlation between $M_{\rm grav}$ and $L_{\rm X}$ (Reiprich & Böhringer, 1999a), here we compare this relation to the relation between $M_{\rm grav}$ and $N_{\rm gx}$. Plottet over $M_{\rm grav}$ for a subset of 66 Abell clusters included in a sample of the X-ray brightest galaxy clusters (*HIFLUGCS*, Reiprich & Böhringer 1999b) are $N_{\rm gx}$ (upper panel) taken from the catalog of Abell et al. (1989) and $L_{\rm X}$ (lower panel).

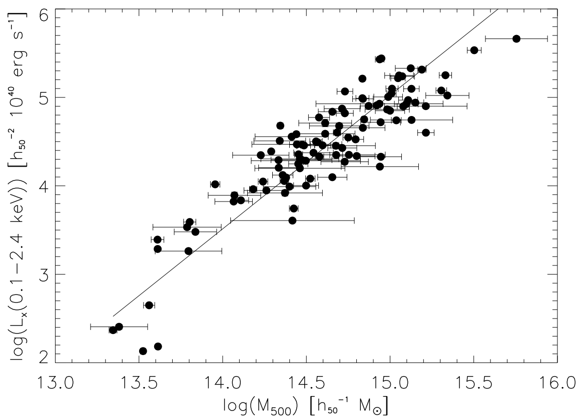

Fig. 3. Currently it is not possible to determine $M_{\rm grav}$ individually for all clusters in surveys containing several hundreds of clusters. Alternatively a quantity which is easily observed and which correlates well with $M_{\rm grav}$ can be used for a mass estimate. The correlation between $L_{\rm X}$ and $M_{\rm grav}$ shown here for 104 clusters has a scatter of about 50% for the mass. This scatter can be taken into account e.g. when the $L_{\rm X}$ function is translated to the $M_{\rm grav}$ function. This relation can also conveniently be applied in large N-body simulations for translating cluster masses to observable X-ray luminosities (e.g. Schuecker et al. 2000).

References:

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Most of these publications and additional information can be retrieved from: http://www.xray.mpe.mpg.de/~reiprich/