Constraining Cosmological Models with the Brightest Galaxy Clusters in the X-Ray Sky

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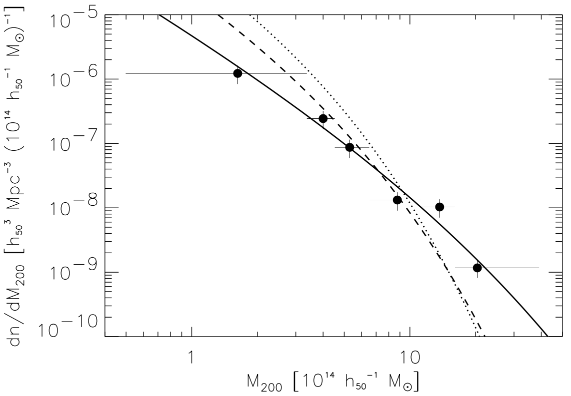
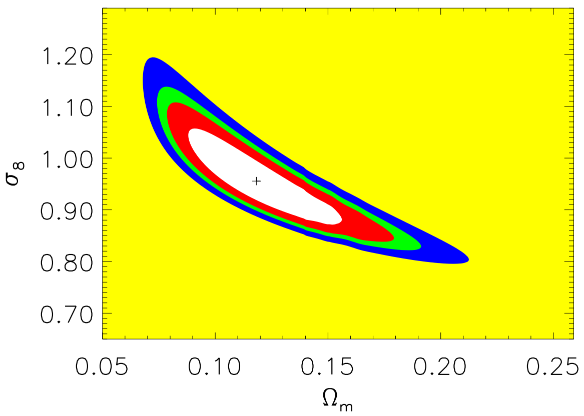
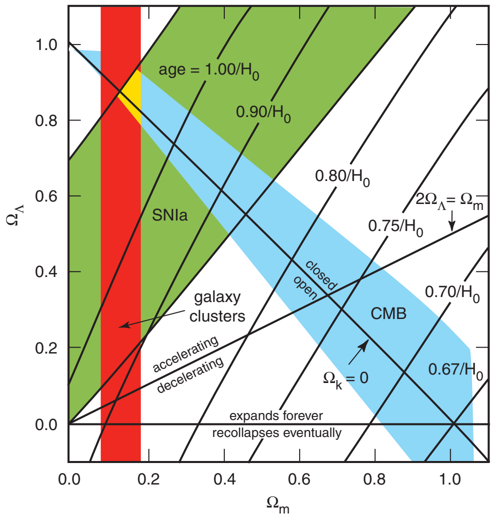
An X-ray selected and X-ray flux-limited sample of the 63 brightest galaxy clusters (excluding ± 20 deg around the galactic plane) has been constructed, based on the ROSAT All-Sky Survey (RASS). A high completeness for the HIghest X-ray FLUx Galaxy Cluster Sample (*HIFLUGCS*) is indicated by several tests. Intracluster gas (ICG) density profiles have been determined mainly from ROSAT PSPC pointed observations. ICG temperatures have been compiled from the literature mainly based on ASCA observations. Gravitational masses have been determined assuming the ICG to be in hydrostatic equilibrium and isothermal. Cluster masses have been compared to masses determined using optical galaxy velocity dispersions (Girardi et al. 1998, ApJ, 505, 74) and using measured X-ray temperature profiles (Finoguenov et al. 2001, A&A, 368, 749). The former masses are systematically higher (factor 1.25) the latter systematically lower (factor 0.8) than the masses obtained here. However, it has been verified that these systematic differences do not significantly affect the constraints on cosmological parameters derived below. *HIFLUGCS* has been used to construct the galaxy cluster mass function, i.e. the cluster number density as a function of mass. Comparison to Press–Schechter (PS) mass functions has allowed to put tight constraints on the normalized mean cosmic matter density, Ω_m, and the amplitude of density fluctuations, σ_8. It has been verified that the slight discrepancies found between the PS recipe and the 'universal' mass function obtained recently from large N-body simulations (Jenkins et al. 2001, MNRAS, 321, 372) do not affect the results given below significantly.



Gravitational mass function determined using *HIFLUGCS* (points) compared to model mass functions calculated with the standard Press–Schechter formalism. Solid line: best fit model, $\Omega_m = 0.12$, $\sigma_8 = 0.96$; dashed line: best fit model for given $\Omega_m = 0.5$ ($\Rightarrow \sigma_8 = 0.56$); dotted line: best fit model for given $\Omega_m = 1.0$ ($\Rightarrow \sigma_8 = 0.43$). One notes immediately that the latter two models give a poorer description of the observations.



Statistical confidence contours for the standard confidence levels (c.l.) 68, 90, 95, and 99 % for two interesting parameters. The cross indicates the best fit result. At the 90 % c.l. it is therefore found that $\Omega_m = 0.12^{+0.06}_{-0.04}$ and $\sigma_8 = 0.96^{+0.15}_{-0.12}$. For comparison for given σ_8 the best fit Ω_m has been calculated yielding roughly the relation $\sigma_8 = 0.43\,\Omega_m{}^{-0.38}$.



In this diagram the constraints obtained here (90 % c.l. statistical uncertainty; red region) are compared to constraints (95 % c.l.) obtained from independent methods. Green region: distant supernovae (Perlmutter et al. 1999, ApJ, 517, 565). Turquoise region: cosmic microwave background (de Bernardis et al. 2000, Nat, 404, 955). Note how nicely the three different methods complement each other. Encouragingly all error ranges overlap; there is a region consistent with all observations. The region of consistency is very close to the line $\Omega_m + \Omega_\Lambda = 1$, where Ω_Λ is the normalized cosmological constant, indicating that the universe has a flat geometry. Furthermore it seems clear that the universe will expand forever. Moreover it appears that it will do so ever faster ($2\,\Omega_\Lambda > \Omega_m$). The implied age of the universe is comfortably larger than the age of the oldest globular clusters. On Wednesday August, 8th this work will be presented in a talk in the old seminar room at MPE at 4 pm. Send an email in case you would like to receive a preprint.