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Are the Inner Cores of Galaxy Clusters Dominated by Dark Matter?

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One of the basic assumptions used in the study of the dark matter in clusters of galaxies (essentially any nonluminous mass source: massive neutrinos, axions, blackholes, bricks) is that this matter has a distribution similar to the galaxies--galaxies are "good" tracers of the dark matter. Unfortunately, when using galaxies, determination of the distribution of the dark matter in the cores of the cluster is very uncertain.[1] Furthermore, the assumption that galaxies are good tracers will be violated at small enough scales where galaxies begin to interact.[2] Therefore, new types of tracers are necessary. Stars from the halos of centrally located galaxies and hot intracluster gas are ideal for these scales. Kinematic/hydrostatic studies[3,4] using these tracers are consistent with a substantial concentration of dark matter in the cores of some clusters. For example, M87 is at the kinematic center of the Virgo cluster. It is undistinguished optically yet it possesses an extension halo of $\sim 10^7$ K intracluster gas.[5] If this gas is in hydrostatic equilibrium, the central region containing M87 and the halo must have mass a factor of 10 greater than the mass accounted for by stars in M87 and by the gas in the halo.[4] We argue that this central concentration or "Black Pit" is an extension of the cluster's dark matter and not a halo as one finds around many spiral galaxies.[6] Galaxy halos, probably dissipationless structures, are easily disrupted and stripped from a galaxy during cluster virialization.[7]

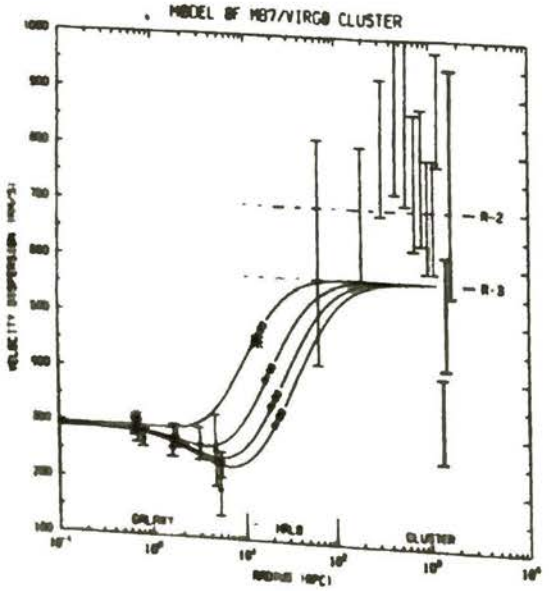


Figure 1 - Models of the velocity dispersion in a Black Pit Potential. Stellar[3], and galaxy[8] velocity dispersion of M87 and the Virgo cluster are plotted versus radius (Virgo cluster distance = 15 Mpc). Model stellar dispersions for Black Pit Models of 20, 40, 60, and 80 kpc are represented by solid lines. Model galaxy dispersions with density distributions of the form r^{-2} and r^{-3} are represented by dashed lines. Also indicated (*) is the approximate result from globular cluster observations[10].

A Black Pit can be characterized roughly by a two component model, one for a central galaxy and the other for the dark matter.[8] The dark matter component lengthscale, A, ranges from ~200 kpc, the usually assumed value, down to 10 to 20 kpc, on the order of a galaxy scale. For the Virgo cluster and M87 we are able to fit a Black Pit model using a combination of the observed intracluster gas[5], stellar[3] and galaxy[9] velocity and spatial distributions. In Fig. 1, the velocity dispersion of M87 is calculated using a r^{-3} density distribution (a King Model) and the cluster velocity distribution using an isothermal model with r^{-3} and r^{-2} density distributions. The corresponding mass distribution is shown in Figure 2. The critical region between the stellar and galaxy regions is

filled using masses derived from the distribution of the hot intracluster medium (Fig. 2). Globular cluster data in this critical region is now just being obtained[10], and is tentatively identified in both figures. The best fit roughly occurs at dark matter length scale of 60 kpc as compared with the commonly quoted scale of ~250 kpc. More complete details will be published elsewhere. This research was partially funded by the National Science Foundation grant number PHY 83-08826.

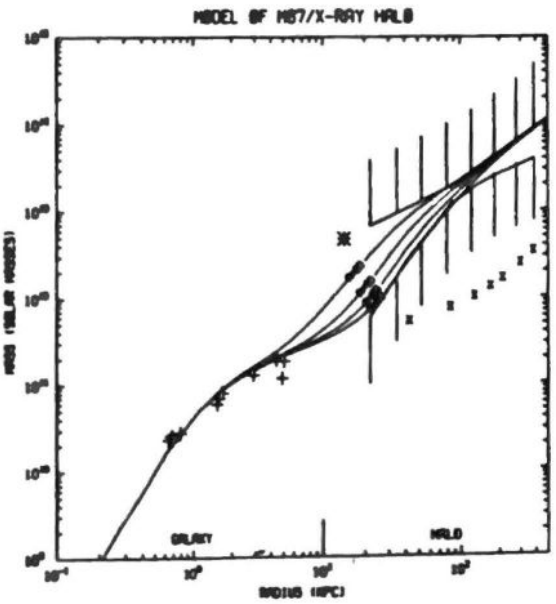


Figure 2 - Models of the mass distribution in a Black Pit Model. Masses inferred from the stellar velocity dispersion[3] are indicated by crosses (+). The total mass in X-ray gas is indicated by X's. The mass range excluded by X-ray observations[4] is indicated by the hatched regions between 20 and 400 kpc. Solid lines represent the mass distribution for a Black Pit Model of core radius 20, 40, 60, and 80 kpc. Again indicated (*) is the approximate result from globular cluster observations[10].

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