HALOS AROUND ELLIPTICALS AND THE ENVIRONMENT DEPENDENCE OF HUBBLE TYPE

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I. Shells and Halos :

Shells are often observed around elliptical galaxies(Malin & Carter 1983). Stars in the shells can be regarded as test particles. Therefore for a simple shell morphology(Hernquist & Quinn 1985) the distances between shells allow one to trace the shape of the potential of the host galaxy(Quinn 1984). One can also deduce the distribution of gravitating material. Following this method one concludes that the distribution of luminous matter alone cannot account for the observed shell structure. Depending on the age of the outermost shell one can conclude that either the massive halo terminates at a radius $\simeq 5\ r_e \simeq 15$ kpc., or that the core of the halo $\gamma \simeq 2.5$ kpc, where the halo density is given by $\rho \simeq \{r^2+\gamma^2\}^{-1}$. In either case, the central density of the halo is no less than an order of magnitude in excess of that expected for a spiral galaxy of comparable luminosity (Figure 1.).

The sample of elliptical galaxies for which shells provide sufficient information about their halos is at present limited. However, unless NGC 3923 is very unusual one is led to conjecture that a typical elliptical has a halo which is far more compact when compared with a spiral with a similar mass.If we accept this correlation between halo parameters and Hubble type as given, we can;(1)Enquire about the origin of this relation and;(2)Attempt to use it to explain other observational facts.

II. Elliptical Halos : Why are they compact ?

In the remainder of this note we accept the idea that galaxies have formed from primordial fluctuations through collapse. This leads one to expect that the baryonic mass of a galaxy(presumably related to its luminosity) is roughly proportional to the amount of dark material in its

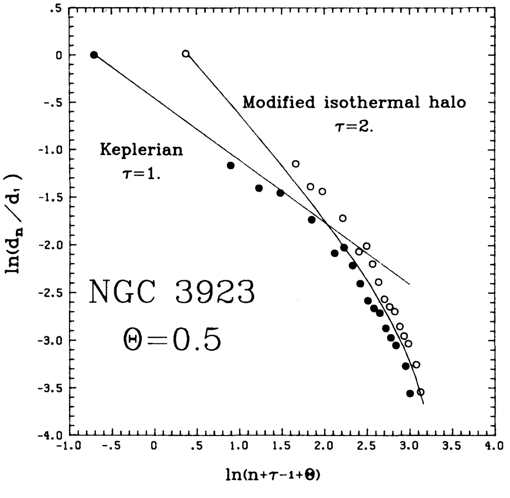

Fig. 1. The distribution of shells around NGC 3923. The outermost shell is labeled 1 and d_1 is its radius. The shell system age is measured in units of the period of the n=1 shell (τ) and Θ =0.5 means the merger occured at zero energy. The shell distribution is NOT consistent with the light distribution of N3923 but requires a halo component that either terminates near $5r_e$ (≃15kpc) or has a small core radius depending on the age of the shell system.

J. Kormendy and G. R. Knapp (eds.), Dark Matter in the Universe, 316–317.

halo, since the baryonic and non-baryonic components of the initial fluctuations have presumably collapsed together. Therefore, it is not surprising that the baryonic material inside the more compact halos will tend to form more compact, luminous ellipticals. What needs to be explained is the difference in the value of the spin parameter (λ). It might be tempting to speculate that more compact, dense halos have systematically smaller values of λ. Such an effect is predicted by linear calculations (Hoffman 1985). Our simulations show that it may exist(Fig.2.) but it appears to be too small compared to the random scatter of the values of λ and ρ to be decisive. It is more likely that the baryonic material has initially similar λ both in the future spirals and ellipticals but compact halos damp out the λ of the dissipative, baryonic material more readily.

III. The Environment Dependence of Hubble Type

Given that for galaxies of comparable mass, elliptical halos are more compact than spiral halos, one can understand the increase in the relative fraction of ellipticals in those regions of the universe which have an overall higher galaxy density. To this end let us consider two galactic size perturbations. Suppose that their relative overdensities with respect to their neighborhoods is the same, δ. Assume that one of the two perturbations exists in a region which is also overdense on a larger scale by a relative factor of Δ. (Such a region may eventually collapse to form an Abell cluster.) Suppose that the other perturbation is inside a region underdense by the same factor of Δ. In spite of the fact that the two perturbations have locally similar sizes, their future fate will differ: the relative overdensity of one of them is $\delta^{+}=\delta+\Delta$, while the other has an overdensity $\delta^{-}=\delta-\Delta$. If we now assume that the spherical collapse approximation (Peebles 1980) applies, then in an Ω=1 universe the densities of the objects they will form after collapse will be substantially different:

$$\frac{\rho^{+}}{\rho^{-}} \propto \left[\frac{\delta+\Delta}{\delta-\Delta}\right]^{3}$$

This strongly suggests that the relative abundance of compact halos will be significantly higher in those regions which are also overdense on a large scale. A more detailed, quantative discussion of this effect will be given elsewhere (Zurek & Quinn 1985 in preparation).

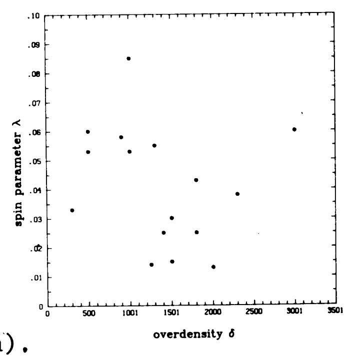

Fig.2. The spin parameter λ as a function of the average halo density after collapse ρ. While there is an indication that λ decreases with increasing ρ, such systematic changes in λ are smaller than its random scatter. These results are from Quinn, Salmon and Zurek 1985 (in preparation).

References

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