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Do Galactic Potential Wells Depend on Their Environment?

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Abstract *Using galaxies in complete samples as tracers of the galaxy density field and about 1000 galaxies with measured circular velocities as targets, we examine the cross-correlation functions between the targets and tracers as a function of galaxy circular velocities. The correlation strength does not vary with the circular velocities except for elliptical galaxies with the highest velocity dispersions, where the effect may well be due to morphological segregations in clusters of galaxies. This is constrasted with the strong dependence of the correlation functions of dark halos on their circular velocities in some models of galaxy formation.*

1. Introduction In order to study galaxy formation and matter distribution in the universe, we need to understand how the intrinsic properties of galaxies are correlated with the large-scale structure. The velocity dispersion (σ) of elliptical galaxies and the rotation velocity (v_c) of spiral galaxies (hereafter termed together as "circular velocities") are important intrinsic properties of galaxies. They are related not only to the process of galaxy formation, but, since they are used as the distance indicators (i.e. Tully-Fisher and D_n-σ relations), also to our study of the large-scale structures and motions in the universe. The dependence of galaxy clustering on galaxy circular velocities is predicted in some models of galaxy formation (e.g. White et al. 1987, hereafter WDEF). It is not yet known whether or not such a dependence exists in observations. In this paper, we examine the dependence of galaxy clustering on the circular velocities of galaxies, using galaxies in complete samples as tracers of the galaxy density field and the $\sim$ 1000 galaxies with measured circular velocities (Mark II release, Burstein, private communication) as targets to study the segregation of the circular velocities by the large-scale structure. We calculate the two-point cross-correlation functions of target galaxies with trace galaxies, which enables us to make a maximum use of the available data and makes possible a direct comparison with theoretical models. Here is a brief report of our results.

2. **Results** To represent the galaxy density field, we use three complete samples of galaxies: the redshift survey of (2Jy) IRAS galaxies (Strauss et al. 1992), the CfA redshift survey of galaxies (Huchra et al. 1983) and the Southern Sky Redshift Survey of Galaxies (da Costa et al. 1991). For the targets representing the circular velocities of galaxies, we use the $\sim$ 1000 galaxy sample of Burstein et al.

We define our problem as follows: Given a target galaxy with a certain intrinsic velocity, what is the expected correlation function of this galaxy with trace galaxies. In this case, we do not need a complete sample for the target galaxies. Fig.1 shows the ratios between the correlation functions for the target galaxies of different circular velocities. To minimize the peculiar-velocity effects, we actually calculated the cylindrical projections of the cross-correlation functions. The horizontal lines represent roughly the predictions given by WDEF for the dependence of the correlation functions of dark halos on circular velocities. There appears to be no trend for the correlation strength to vary with the circular velocities. This is true for both elliptical and spiral galaxies, except for elliptical galaxies with the highest velocity dispersions ($\sigma \gtrsim 280\,\mathrm{kms}^{-1}$), where the effect may well be due to morphological segregations in clusters of galaxies. The circular-velocity dependence in the observation is at a significantly lower level than the model predictions, if the observed circular velocities are correlated with the circular velocities of dark halos.

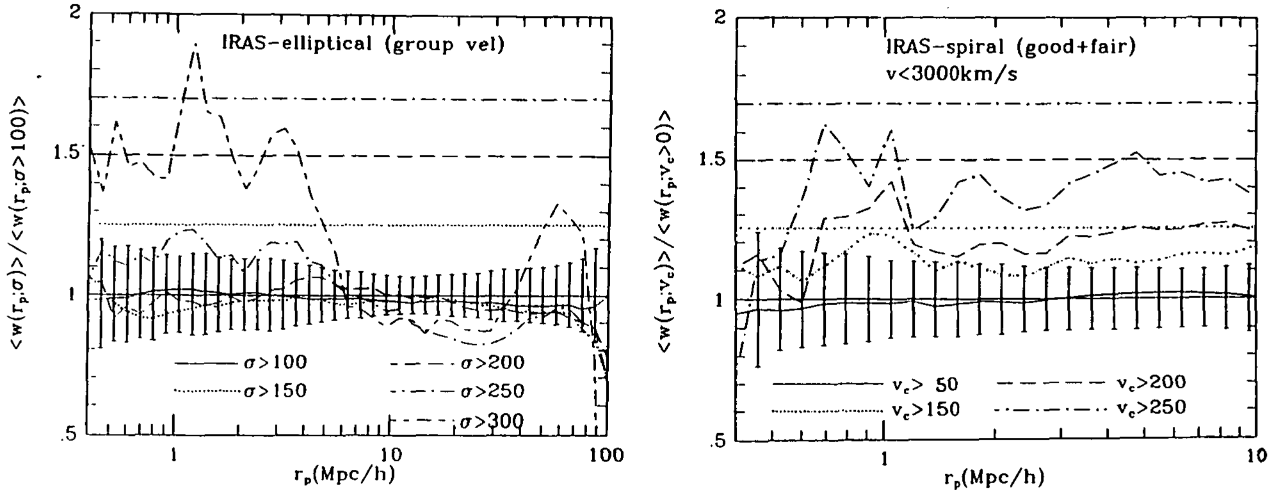

Fig.1. (a) The ratios between the projected correlation functions of different σ-samples of elliptical galaxies and that of the total sample. IRAS galaxies are used as tracers. The error bars represent 1σ bootstrap errors for the $\sigma > 250\,\mathrm{kms}^{-1}$ sample. They are about two times as large for the $\sigma > 300$ sample and slightly smaller for other samples. The horizontal lines represent the enhancements of the correlation functions of dark halos by circular velocites, predicted by the "natural" biasing model (WDEF). (b) The same as (a) but for spiral galaxies of different v_c. The error bars represent 1σ bootstrap errors for the $v_c > 200\,\mathrm{kms}^{-1}$ sample. They are about two times as large for the $v_c > 250$ sample and slightly smaller for other samples.

Following Kaiser (1989), we write the modulation of the circular velocity v_c of a dark halo by a long-wavelength density pertubation $\Delta_B(0)$ (at the present time) as

$$v_c'[z_f, \Delta_B(0)] = v_c(z_f)\left[1 + \frac{\Delta_B(0)}{1.68(1+z_f)}\right]^{\frac{(1-n)}{2(n+3)}} \approx v_c\left[1 + \frac{0.3(1-n)}{n+3}\frac{\Delta_g(0)}{b_g}\frac{1}{1+z_f}\right]$$

where z_f is the redshift at collapse, n is the power-spectrum index of the density fluctuations, and the large-wave-length *galaxy* density fluctuation Δ_g is assumed to be related to the matter density fluctuation by $\Delta_g = b_g\Delta_B$ (b_g is the biasing parameter). We estimate the density Δ_g around the target galaxies from our cross-correlation function. The weak variation of v_c with Δ_g in our analysis can be used to set the limit $(1-n)/[(n+3)(1+z_f)b_g] \lesssim 0.2$. To satisfy the Tully-Fisher relation $L \propto v_c^4$ and assuming that mass $M \propto L$, one gets $n = -2$. If $b_g = 1$ then $z_f \gtrsim 10$, which means that most halos were formed at a quite early epoch.

References

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