A Test of Galaxy Evolutionary Models Via Angular Sizes

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The relationship between angular size, magnitude, and redshift of faint galaxies is explored as a potential tool to distinguish between different galaxy evolutionary models. Different models, based on merging, mild luminosity evolution and no evolution, lead to different predictions of the angular size distribution, redshift-size relation, and magnitude-size relation.

The merging model predicts significantly smaller sizes for faint galaxies than the standard model, because of the requirement for more intrinsically small faint objects at high redshift. A dwarf-rich no evolution model also predicts small sizes for faint galaxies. The mild luminosity evolution model predicts more luminous galaxies of large angular size at high redshift, as does a standard no evolution model.

Pre-refurbishment HST observations of magnitudes and sizes of faint galaxies indicate an excess of small vs. large faint galaxies, favoring the dwarf rich, no evolution model with respect to the merging model; the other two models are more discrepant with the data. While these results cannot yet be used to rule out with certainty any of the proposed models, they demonstrate the potential of angular size to discriminate between models of galaxy evolution, especially with the high-resolution HST WFPC2 data.

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1 Outline

We have studied what we can learn about galaxy evolution by using angular sizes of faint galaxies. Section 2 list models we used for this analysis. Section 3 explains the tests to distinguish evolutionary models. Section 4 compares the result from HST data with the model predictions. Section 5 gives the summary.

2 Models

We tested the following 4 models by preforming Monte Carlo simulations of each model.

1) Merging Model (Broadhurst et al. 1992, with Q=4, b=4)

2) Mild luminosity evolution model (mild LE model; Guiderdonni & Rocca-Volmerange, 1987)

3) Standard no evolution (NE) model

4) Dward Rich NE model (Driver et al. 1994)

3 Results & Discussion

3.1 *Angular size distribution test*

Fig. 1 shows the angular size distribution from various models in the different apparent magnitude ranges. The merging model and the dwarf rich NE model predict smaller angular sizes compared to the standard NE model and the mild LE model. This is due to the lack of high redshift galaxies which are larger than lower redshift galaxies at a fixed magnitude. The merging model has some high redshift galaxies, but they are intrinsically small.

The difference between models becomes more evident at fainter magnitudes, until it reaches the very faint magnitude limit where galaxy sizes converge to very small values.

In fig. 2, we plot the angular size vs. magnitude for the different models.

3.2 *Angular size dependence on redshift distribution*

The observed fraction of galaxies at $z > 1$ in a magnitude limited sample is dependent on their angular sizes. For a fixed apparent magnitude, the larger galaxy (lower surface brightness) tends do have the larger redshift, mainly due to the surface brightness dimming effect in the expanding universe.

In fig. 3, we see that galaxies selected with $r > 1$ arcsec are about 3 times more likely to be at high redshift than size-independently selected sample. This kind of selection criteria may help detecting high redshift galaxies with less effort.

4 Comparison of models with data

In fig. 4, we compare the angular size distribution of galaxies obtained from the Medium Deep Survey, a HST key project, with the model predictions. In fig. 4, we can see the lack of large galaxies and the excess of small galaxies compared to the mild LE model and the standard LE model. The dwarf rich NE model seems to match the distribution best, and the merging model is not so far off by looking at χ^2 value.

The data is from only one field so far, therefore it is premature to claim that any of evolutionary model is excluded by looking at fig. 4.

5 Summary

We have investigated possible tests for various evolutionary models using angular sizes of galaxies. The dwarf rich NE model and the merging model favor the smaller sizes, and the standard NE model and the mild LE models favor the larger sizes. For a fixed apparent magnitude, larger and lower surface brightness galaxies tend to be at higher redshift because of the surface brightness dimming effect.

The comparison of the data with the model predictions via angular size distribution shows that the dwarf rich NE model and the merging model are prefered over the mild LE model and the standard NE model, but greater numbers of galaxies are needed to get firmer conclusions.

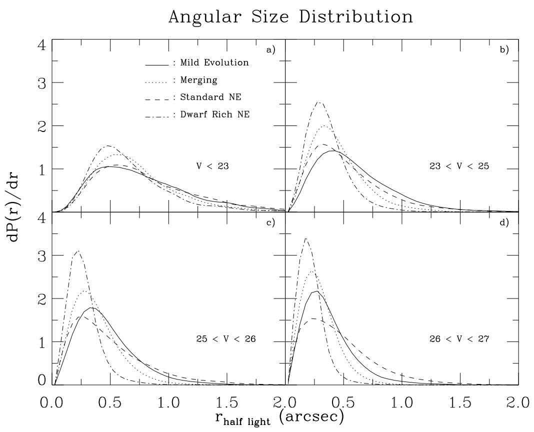

Figure 1: The angular size distribution of galaxies predicted according to various models in the apparent magnitude range (a) $20 < V < 23$, (b) $23 < V < 25$, (c) $25 < V < 26$, (d) $26 < V < 27$. Each line corresponds to a different model, as follows: solid for mild LE, dotted for merging, dashed for standard NE, and dot-dashed for dwarf-rich NE.

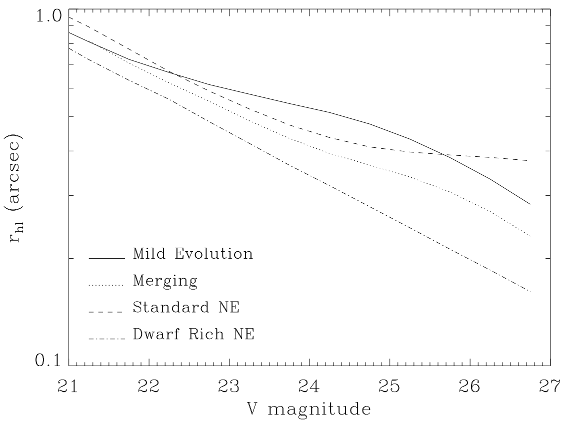

Figure 2: Angular size vs. apparent magnitude for different evolutionary models. Each line represents the median angular size as a function of apparent magnitude for an evolutionary model as in Fig.1.

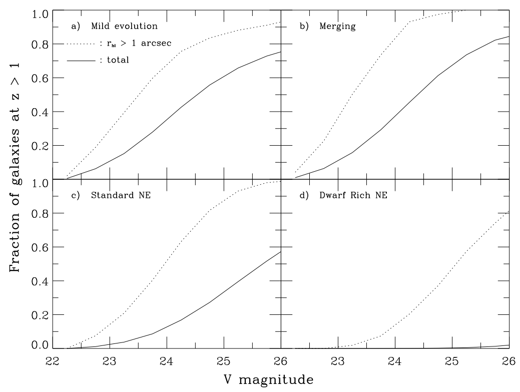

Figure 3: The fraction of galaxies ($23 < V < 25$) with redshift higher than $z > 1$ for size-independent selection (solid line), and for selection with $r > 1$ arcsec (dotted line).

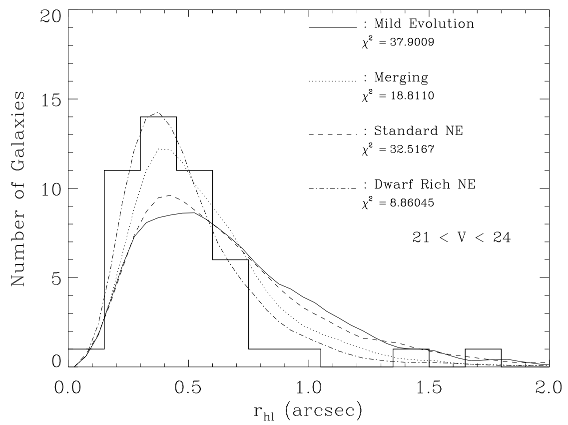

Figure 4: The angular size distribution of galaxies ($21 < V < 24$) from the HST Medium Deep Survey is compared with the model predictions.