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Mergers at z=1

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ABSTRACT Multiband images of nearby interacting pairs of galaxies, mergers, and normal field galaxies are used to simulate images of high redshift mergers by identifying distinctive morphological features. Preliminary results indicate that it is feasible for the HST to detect these high redshift objects.

I. Introduction

The study of interacting galaxies may help us understanding of galactic evolution and galaxy formation. Observations of ellipticals with counter-rotating cores and ellipticals with multiple nuclei suggest their origins by the process of merging of spirals (Schweizer 1986, 1989; Kormendy 1989, & Wielen 1989). However, van den Bergh (1989) and others objected this idea based on the argument that the observed number of globular clusters per unit luminosity is higher than the sum of two spirals merging together. More recent studies of globular clusters in interacting systems by Ashman and Zepf (1992), and the HST detection of excess young blue globular clusters in NGC1275 support the interpretation that they were formed by merging (Holtzman *et al* 1992).

Moreover, the excess blue objects counts in deep sky surveys (e.g. Lilly *et al* 1991, Cowie *et al* 1991) suggests the possibility of merging plays an important role in the formation of galaxies. Overabundance of paired objects in deep sky survey have been reported by Zepf and Koo (1989), and most of the objects have been confirmed spectroscopically (Smetanka 1991). In order to evaluate the importance of merging events in the role of galaxy formation and to test the hypothesis that merging rate was higher at high redshift, it is crucial to find these objects in deep sky surveys.

The purpose of this paper is to illustrate the potential of using distinctive morphological signatures in nearby interacting systems as criteria to search for these candidates at high redshift with the HST.

II. Sample Selection and Observation

The selection criteria for the nearby merger candidates is similar to those of Karachentsev (1980) with additional restrictions:

(1) both members need to have accurate radial velocities measurements,
(2) the projected separation between the pairs is less than 200kpc,
(3) the angular separation is less than two arcminutes, and
(4) the candidate does not belong to a group or having a third member within 500kpc from their center.

The normal field galaxies come from two sources. One sample of field galaxies is from the sample used by Green, Anderson, and Ward (1992), and the other sample from a complete random selection from UGC catalogue.

All the observations were made from the Apache Point Observatory 1.8m reflector, using the High Resolution Imager (a TI800x800 CCD) with B, V, R, I, g, r, i filters . The average total exposure for an image is about an hour with the HRI; generally broken into 10 minutes segments, each a slightly different positions. These short images were aligned and median to produce the final image.

III. Data and Simulation

B, V, R broadband images of Arp243 have been obtained during February 24 to 26, 1992 (see figure 1a, 1c, 1e, respectively). The average seeings of those nights is about 1.6 arcsecond. The B and R band images are each 50 minutes exposure, and the V band image is only 10 minutes exposure. Morphological features, such as knot and bridge have been detected with size about 4kpc extended from the oval nucleus of the galaxy. We then use these images and simulate their appearances as if they are at z=1. For z=1, $q_0 = 0.5$, and h = 0.75 model, the angular size for structures of 4kpc is about 0.704 arcsecond, and it is feasible for the HST to resolve these structures as it is demonstrated by figures 1b, 1d, and 1f. The data and simulation are generated by using the IRAF software packages.

The figures are in counts per pixel after sky-subtraction, the background is nominally zero. Figures 1a, 1c, 1e are Arp243 in B, V, and R band respectively. The size of the box is 130x130 arcsecond or 46x46kpc, and the pixel scale is 0.467arcsecond per pixel. Figures 1b, 1d, 1f are simulated HST images of Arp243 at z=1 with respect to the B, V, R band images. The size of the box is 8x8 arcsecond, and the pixel scale ranges from 0.045arcsecond per pixel for Planetary Camera to 0.1arcsecond per pixel for the Wide Field Camera of the HST.

IV. Discussion

Although the simulation did not include noise or the degraded point spread function of the HST, it did not affect our results. The crucial aspect of the simulation is whether we could identify disrupted morphologies at high redshift objects with the HST within reasonable observation time; and the simulated images do preserve the distinctive morphological signatures. Whether this can be done before the planned instrument upgrade is an item of further study.

Disrupted morphologies of interacting systems have been successfully accounted for by calculations of direct collision of galaxies (Toomre & Toomre 1972, etc). According to the model of Olson and Kwan (1990) enhanced star formation and morphological peculiarities are frequently found in or near the nuclei of the interacting pairs. Near-infrared images of peculiar galaxies from the Arp atlas have revealed a number of interesting morphological features that appear in theoretical calculation (Bushouse & Stanford 1992). Although the Arp sample is selected because of morphological peculiarities, it is pointed out by Madore (1985) that the majority of the sample is made up of interacting galaxies. Therefore, it is natural to assume that high redshift interacting systems will also show morphological peculiarities that are found in nearby interacting systems.

The major problem we need to resolve is the issue of completeness of the sample. The objects detected in this way are subject to bias towards strongly interacting systems. Systems that are not *active* may not be detectable in this way. We may assume that the distribution of interacting systems with different activity levels are invariant with time and only the rate of merging changes with time, then we could compare the rates of merging of similar systems in different epoch. Unfortunately, the above ad hoc assumption could not be tested.

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Figure 1a: The lowest contour corresponds roughly to a surface brightness of 25.8mag/arcecond^2 in B band.

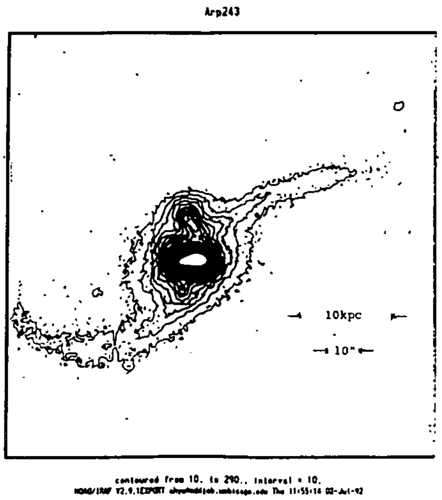

Figure 1b: The lowest contour corresponds roughly to a surface brightness of 28.8mag/arcecond^2.

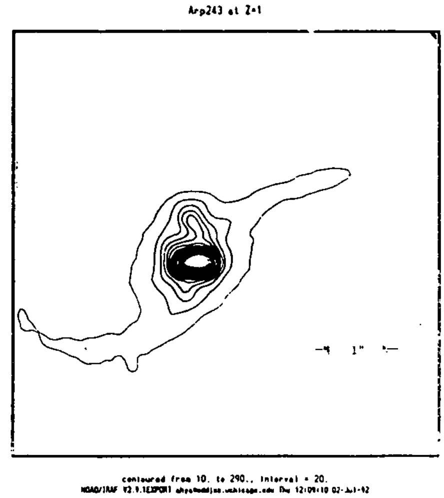

Figure 1c: The lowest contour corresponds roughly to a surface brightness of 24.2mag/arcecond^2 in V band.

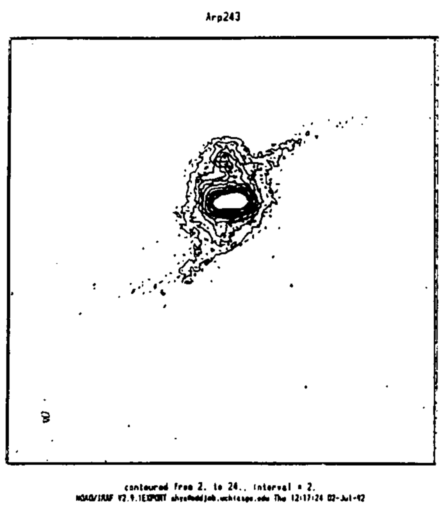

Figure 1d: The lowest contour corresponds roughly to a surface brightness of 27.2mag/arcecond^2.

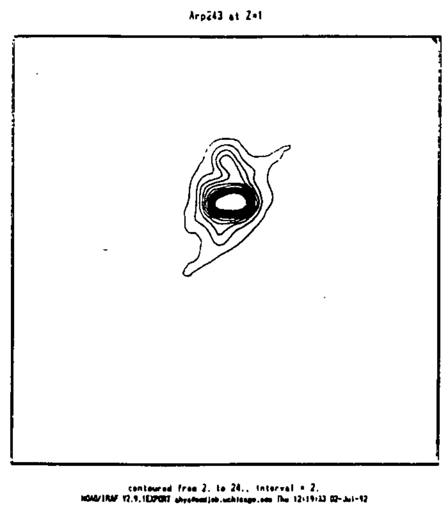

Figure 1e: The lowest contour corresponds roughly to a surface brightness of 24.8mag/arcecond^2 in R band.

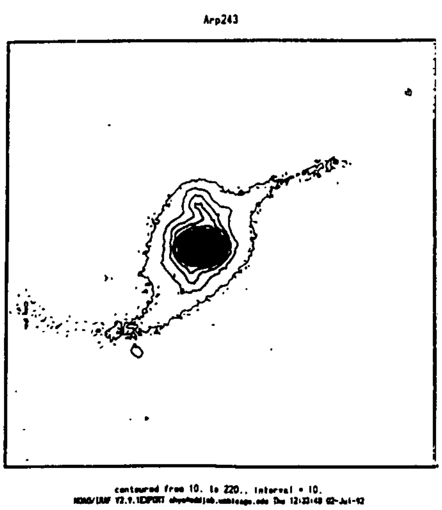

Figure 1f: The lowest contour corresponds roughly to a surface brightness of 27.8mag/arcecond^2.