

## **DYNAMICAL SUBSTRUCTURE OF GALACTIC GLOBULAR CLUSTERS**

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### **ABSTRACT**

We used BV CCD images to study the dynamical substructures of three globular clusters – M5, NGC6934, NGC7006 – analyzing the radial variations of ellipticity and position angle from the point spread function stellar photometry and the ellipse surface photometry. Several populations were classified by the brightness on color-magnitude diagrams of each globular cluster. Ellipse analyses to the images, removed stars of each population from the original images of the clusters, show radial variations in ellipticity and position angle, with the amount of  $0.01 \sim 0.25$  in ellipticity and  $+90 \sim -90$  degrees in position angle up to roughly three times of half light radius ( $r_h$ ). It is also apparent that there are no significant discrepancies in the dynamical substructures beyond  $r_h$  among the different populations. However, dynamical substructures on the central region (i.e., inner than  $\sim r_h$ ) reflect the contributions of populations of bright red giant stars and horizontal branch stars.

*Keywords:* globular cluster, dynamical substructure

### **1. INTRODUCTION**

Two simple observational effects on the dynamical structures of Galactic globular clusters are the mass segregation and the shape of the system. Because of the equipartition of energy, slower-moving more massive stars are more concentrated toward the center of the cluster than the less massive stars (Grindlay et al. 1988, Nemeč & Harris 1987). And, the images of Galactic globular clusters are slightly elliptical (White & Shawl 1987, Fall & Frenk 1985), although the distribution of light in a cluster is almost specified by the radial brightness profile, since they appear remarkably spherical. Considering the correlation between these two, we test the effect of the distribution of stellar populations on the dynamical structure of globular clusters. To do this, we analyzed variations of ellipticity ( $\varepsilon = 1 - b/a$ ) and position angle (PA) of globular clusters as subtracting a particular population from the original image of globular cluster (Rhee & Sohn 2004).

### **2. DATA, STELLAR PHOTOMETRY, AND POPULATIONS**

BV CCD images of three globular clusters were recorded  $f/7.5$  focus on the 0.9m telescope at KPNO in September 1, 1998. The image scale is  $0.68''/\text{pixel}$ , and each image covers  $23.5' \times 23.5'$

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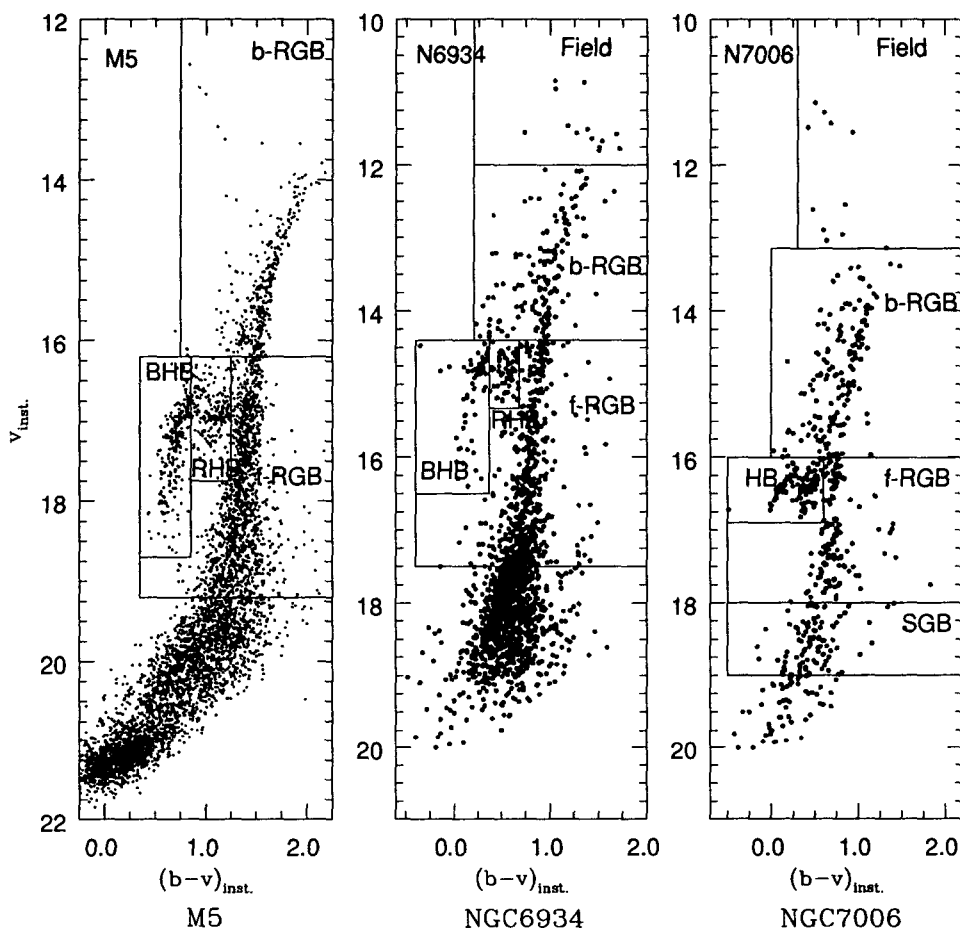


Figure 1. CMDs and population classification of M5, NGC6934, and NGC7006.

area. The brightnesses of individual stars were measured with the PSF routine DAOPHOTII/ALLSTAR (Stetson & Harris 1988). On the final CMDs of each cluster, we arbitrarily classified populations of stars by their brightness. The CMDs and their classified populations in each cluster are shown in Figure 1. Stars are classified into 4 populations of b-RGB, BHB, RHB, and f-RGB for M5 and NGC6934, and b-RGB, HB, f-RGB, SGB for NGC7006.

### 3. DYNAMICAL SUBSTRUCTURES

To examine the dynamical substructures for each cluster, we first subtracted stars of each population classified in Figure 1 from the original  $V$  image. And then we applied the ELLIPSE task (Busko 1996) in IRAF/STSDAS on the smoothed images of each cluster, from which we derived radial distributions of  $\epsilon$  and PA. Figure 2 shows the radial variations of  $\epsilon$  and PA on each images

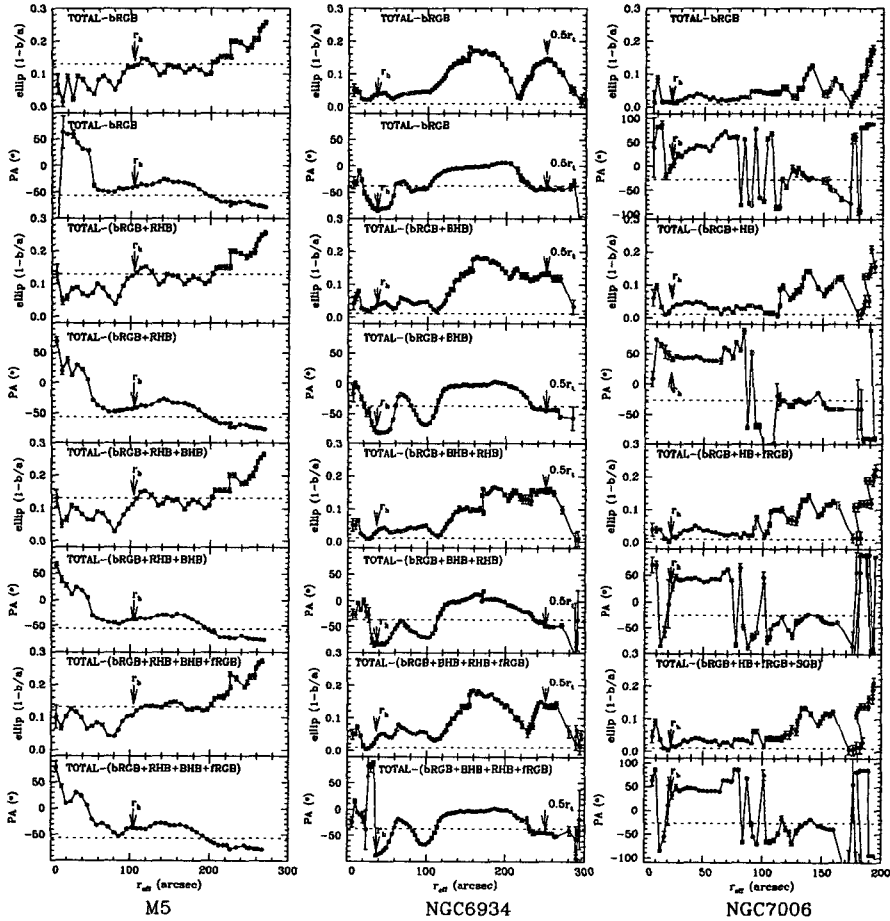
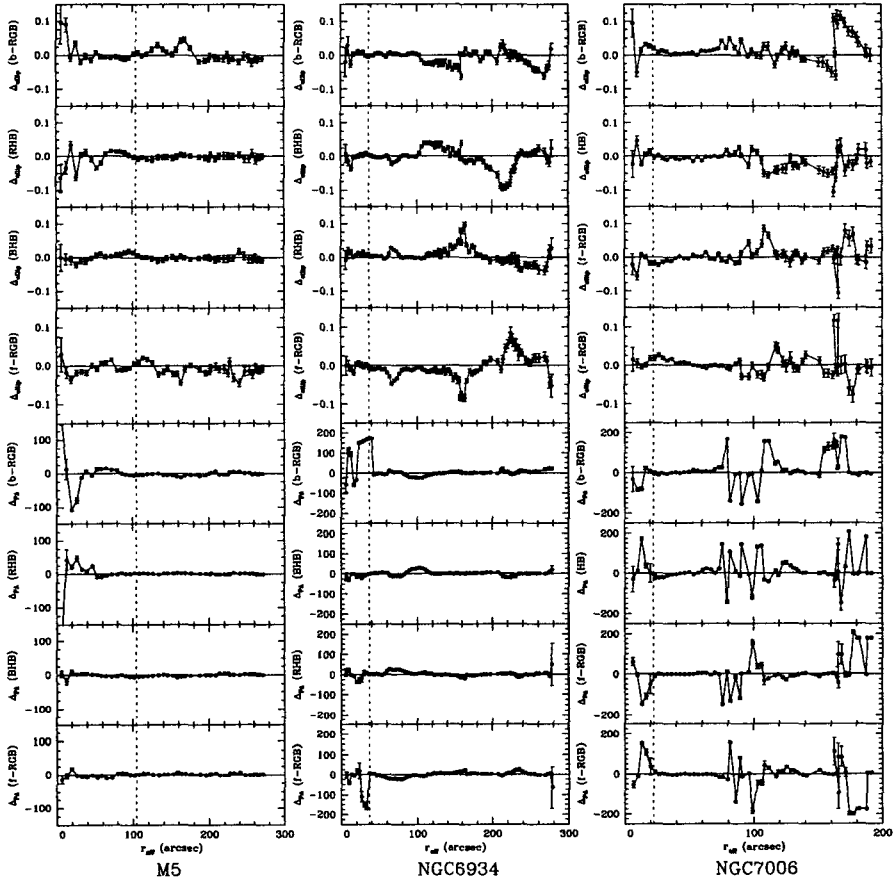


Figure 2. The radial variations of  $\epsilon$  and PA on each images subtracted stars of each population from the original image.

subtracted stars of each population.

To see the effects of each population on the variations of  $\epsilon$  and PA for each cluster, we estimated the residual values of them which are the values derived from the original image minus those from the image subtracted each population (Figure 3).

Ellipse analyses of Figure 2 and Figure 3 in consideration of different populations for each cluster show radial variations in ellipticity and position angle, with the amount of  $0.01 \sim 0.25$  in ellipticity and  $+90 \sim -90$  degrees in position angle up to roughly three times of half light radius ( $r_h$ ). It is also apparent that there are no significant discrepancies in the dynamical substructures beyond  $r_h$  among the different giant populations. However, dynamical substructures on the central region (i.e., inner than  $\sim r_h$ ) reflect the contributions of populations of bright red giant and horizontal branch stars.

Figure 3. Residual plots of radial  $\epsilon$  and PA variations for each cluster.

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