THE STRUCTURE OF COLLAPSED CLUSTER CORES

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ABSTRACT. In order to test the prediction that many Galactic globular clusters have undergone core collapse (Lightman 1982, Cohn and Hut 1984) and should therefore have central surface brightness cusps, we have obtained UBVR CCD frames of the cores of 72 clusters. We present and analyze U-band surface brightness profiles for three clusters: one "control cluster" with a normal flat core profile — NGC 6388 — and two with central power law cusps — NGC 6624 and M15 (NGC 7078).

1. INTRODUCTION

The predicted observational signature of a cluster that has undergone core collapse is a central surface brightness cusp — a surface brightness profile that continues to rise as a power law at small radii in contrast to a normal King type profile that becomes flat within the cluster core. During the past several years there has been mounting observational evidence for central surface brightness cusps in some globular clusters. Djorgovski and King (1986) have recently reported definite cusps in 21 clusters and possible cusps in 7 others out of 123 clusters surveyed, mostly using CCD data in the BVR bands.

2. OBSERVATIONS

We have concentrated on obtaining U-band frames of globular cluster cores, in addition to BVR frames, using RCA CCD chips on the CTIO 4 m, CFH 3.6 m, and KPNO #1 0.9 m telescopes. U-band surface brightness profiles are less dominated by individual red giants and are thus less "noisy" and more representative of the underlying mass distribution than are longer wavelength profiles (King 1985). To date we have obtained data for 72 clusters, with at least one complete set of UBVR frames for most clusters. We present U-band profiles for NGC 6388, which has been cited as a prototypical normal cluster by Djorgovski and King (1986), and for NGC 6624 and M15, which have both been reported to show central surface brightness cusps in several previous studies. We observed NGC 6388 and NGC 6624 from CTIO in May 1985 and observed M15 from KPNO in May 1984. We also observed the latter two from CFH in July 1986; analysis of these new data is underway.

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3. RESULTS

We have determined cluster centers and surface brightness profiles from our CCD frames using software kindly provided by S. Djorgovski and I. King. The U-band images of NGC 6624 and M15 show central surface brightness "spikes" about 2-3" in radius which are centered within 0.5" of the autocorrelation cluster centers. Our profiles (Fig. 1b,c) indicate that these spikes represent the central few arcsec of power law cusps that extend out to about 10" in both clusters.

We first attempted to fit the entire profiles of the clusters with seeing-convolved King models, obtaining a reasonable fit for NGC 6388 (Fig. 1a). No acceptable King model fits to the entire profiles of NGC 6624 and M15 could be obtained. We next fit the inner profiles of the clusters with seeing-convolved power laws, varying the outer radius of the fit region from 5" to 40". While there is no particularly good fit of this model to the inner region of NGC 6388, it gives a good fit to the central regions of both NGC 6624 and M15 out to a radius of about 10", indicating that the the core radii of these clusters are unresolved at a level of about 0.75" (the seeing HWHM). The best fit power law slopes of -0.77 for NGC 6624 and -0.64 for M15 are significantly flatter than the value of -1 predicted for a post-collapse cluster of identical stars. This indicates the presence of nonluminous remnants — possibly massive white dwarfs — that are more massive than the stars that dominate the luminosity profile (Lee, this volume).

We find that King models provide excellent fits to the *outer* ($r \gtrsim 10$") regions of NGC 6624 and M15 (Fig. 1b,c), as expected from computer simulations of clusters undergoing core collapse (Cohn 1980).

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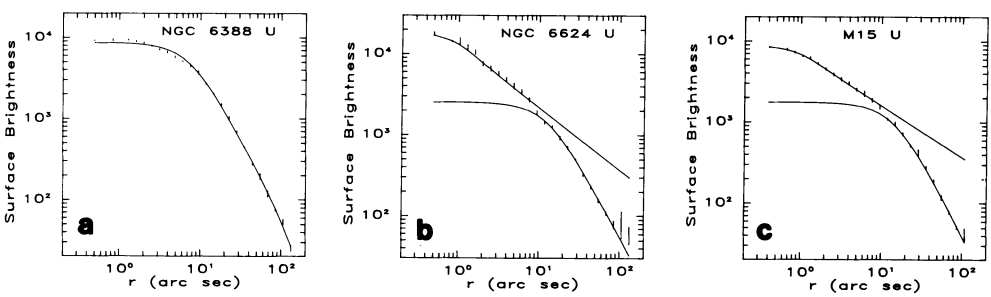

Fig. 1. King model fit to entire profile of NGC 6388; power law fits to inner regions and King model fits to outer regions of NGC 6624 and M15.