INTEGRATED INFRARED PHOTOMETRY OF GLOBULAR CLUSTERS

I. Recent Infrared Photometry of Globular Clusters and the Techniques of Integrated Wide-Field Photometry

C. J. BADDILEY
Department of Astronomy, University of Manchester, England*

(Received 10 August, 1979)

Abstract. The recent literature on infrared photometry of globular clusters is briefly reviewed, and an alternative approach to this kind of photometry is presented. This alternative — integrated wide field photometry, is the subject of Papers II and III, with a full description of a working instrument in Paper II and some initial results in Paper III.

1. Introduction

Although UBV photometry of globular clusters has been a common pursuit of numerous authors, little photometry has been done in the infrared on these objects. This is a most unfortunate imbalance; a significant part of the near infrared radiation of most galaxies is from cool late population stars — especially in the cores (Johnson, 1966a; Glass, 1973, 1976; Allen, 1976) and a detailed study of the infrared properties of the globular clusters in our own galaxy should reveal considerable similarities to them.

2. Recent Literature

Until recently infrared photometers have not been used to detect globular clusters. There are several reasons for this, but perhaps the most obvious restriction is the extreme difficulty in locating individual star members of a cluster on the cross-wires of a telescope, due to the high stellar concentration of the field and the extreme faintness of the objects. It is also near impossible to find a convenient guide star and guide with sufficient accuracy to keep the object star centred in the field and to keep all other stars out of a 20 arcsec detection beam and the reference beam. Recent advances in infrared detector technology have now placed the brighter red giant members of globular clusters within the noise limits of a good infrared photometer.

It is clear then that only the nearest and brightest clusters are worth studying in this way, and indeed the $J$, $H$, $K$ photometry of red giants in CO Centauri has been undertaken by Glass and Feast (1977). Their paper includes $J$, $H$, $K$ data for 15 red

giants, 5 non-TiO variables, 4 TiO variables and 3 others. They observe a reduction in the spread of the giant branch in an $R$ vs. $(R - I)$ plot as compared with $V$ vs. $(B - V)$ or $K$ vs. $(J - K)$; they suggest that many of the giants with redder $(B - V)$s suffer molecular absorption in the blue and an associated excess in the infrared. Cohen et al. (1978) have observed giants in M3, M13, M92 and M67 in $J$ (1.25 $\mu$m), $H$ (1.65 $\mu$m), $K$ (2.20 $\mu$m) and also CO (2.00 $\mu$m), $H_2O$ (2.36 $\mu$m), and 2.20 $\mu$m (continuum), and obtained bolometric magnitudes and effective temperatures. The broadband colours are successfully predicted, and effective temperatures independent of surface gravity or metal abundance for metal poor stars are obtained from the $V - K$ measurements. The relative M3 to M13 metal abundance from the CO band measurements was reversed from other published data and the CO index was found to become sensitive to metal abundance for metal poor stars.

The $UBV$ photometry of stars in globular clusters is extensive, and this subject has been pursued recently with renewed interest using the more sensitive photographic emulsions. Such photometry by Lloyd Evans (1975) has shown that many of the giant branch anomalies and metal-poor anomalies found in globular clusters are in fact an observational selection effect. This new $UBV$ data is extremely useful in interpreting infrared observations.

WIDE FIELD PHOTOMETRY

Of the total listed sources in the 2.2 $\mu$m Infra-Red Catalogue, there are only three coincident with globular clusters. The source IRC-20498 is thought to be detectable at $K$ and is coincident with NGC 6656, and Cohen (1971) suggests it is an extended source within the cluster.

In order to study all but the nearest and most open clusters in the infrared, an alternative method must be considered. Most catalogued clusters visible to the telescope subtend an angular diameter between 40 arcsec and 4 arcmin, and have a typical integrated visible magnitude of 7 to 11. The standard field aperture of an infrared photometer of 20 to 30 arcsec is insufficient to accept the total integrated radiation from these objects. With a few exceptions attempts have been unsuccessful. These objects are faint, due to their distance, and are often on the detection limits of standard photometers. Cohen and Fawley (1974) list 9 objects observed at $N$ (10 $\mu$m) with a few at $K$. They used an 11 arcsec beam and 15 arcsec beam separation; the narrow beam was presumably required due to the high sky noise at 10 $\mu$m. There were no clear positive detections at $N$, and only certain limits could be given for detections at $K$. The 15 arcsec beam separation would have left the wings of the sources in the reference beam thus reducing the difference between beams. If the red giants were concentrated in the cores of these clusters, Cohen and Fawley would have expected significant results. Such a detection at $N$ has been published by McGregor et al. (1973) on the 10 arcsec core of NGC 7078 with a 3 $\sigma$ signal as $N = 1.6 \pm 0.3$. This observation raised the question as to whether the radiation was from dust around a single