THE CLUMP GIANTS: A SPECTROSCOPIC SURVEY OF G AND K GIANTS IN OPEN CLUSTERS

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1. INTRODUCTION AND OBSERVATIONS

The clump giants in old and middle-aged open clusters provide a sample of stars whose evolutionary state can be clearly identified as core helium burning (Cannon 1970). The evolutionary state of the Ba II stars, on the other hand, is at present undetermined. The enrichment of s-process elements in the atmospheres of these peculiar stars suggests that the stars have at least passed through double shell burning, where the heavy elements may be produced and mixed to the surface. The Ba II stars are, however, too faint to be associated with this phase of stellar evolution; the absolute magnitudes and temperatures are consistent with the core helium burning phase. The barium stars should then occur in the clumps of Population I clusters in similar proportion to their numbers among the field giants.

A systematic spectroscopic survey of clump giants is in progress using the Cassegrain image tube spectrograph of the 2.2 m telescope of the Mauna Kea Observatory. Clusters have been selected for observation from among those with well-defined and well-populated clumps. A total of 82 giants in 14 open clusters, including NGC 752 and Praesepe, reported here, have been observed. Eleven MK standards of similar temperatures and luminosities, and eleven barium stars have been observed for calibration purposes. The earliest main sequence stars in each cluster are also being observed for rotation velocities.

The spectra cover the region from Ca II H and K through Hα at 50 Å mm^{-1}. The half width of the instrumental profile is 2 Å.

A. G. Davis Philip and D. S. Hayes (eds.), The HR Diagram, 157-160.

Intensity tracings of the plates have been produced with equipment at the University of Hawaii. Equivalent widths have been measured with respect to the local continuum for approximately 30 features on each of the tracings. Lines which are used in spectral classification in this part of the HR diagram were selected from those which are relatively free of blending, or are blended with lines of similar characteristics. Intensities at two points in the G band and at 4208 Å in the CN band were also measured.

2. ANALYSIS

From the line strength measurements a set of seven spectral indices was constructed: hydrogen line strength (Hα+Hβ+Hγ), calcium line strength (4226 Å), overall metal line strength (Cr I 4565, Fe I 4647, Fe I 4667 Å), barium (4554, 4934, 6141 Å), strontium (4077, 4215 Å), CN, and CH. Except for the overall metals, each index was normalized to the strength of nearby iron peak metal lines.

The ratio of hydrogen index to calcium index was chosen as a temperature parameter. The hydrogen lines are most sensitive to temperature through G type stars, while 4226 Å increases strongly with decreasing temperature through the K giants. The ratio of H/Ca correlates with (B-V) for normal field giants, but more observations are needed to calibrate the relationship. No simple luminosity indicator could be found. For this study of clump giants a luminosity indicator is not required since relative V magnitudes are available for stars in a cluster.

The barium index is clearly higher for the field barium stars, even the marginals, than for normal standards, including the two class II stars (Fig. 1). A stellar mass effect is also apparent from examination of the data for three groups of stars: the field stars, the Praesepe giants, and the NGC 752 giants. The mean Ba index for each group appears to correlate with cluster age. Praesepe is a younger cluster than NGC 752, and its giants are more massive than those in the older cluster. At the same L and T_{eff}, log g will be higher in Praesepe, so the Ba II lines will be weaker.

The G band index behaves similarly with H/Ca as with spectral type, remaining constant through the G type stars, and dropping sharply in strength in the early K's. NGC 752 and Praesepe giants both have normal CH, and some, but not all, of the Ba II stars have enhanced CH. CN appears enhanced in most of the Ba II and CN stars, and not in the bright giants. Praesepe giants appear to have slighly strong CN. Some, but not all of the NGC 752 giants have weak CN.

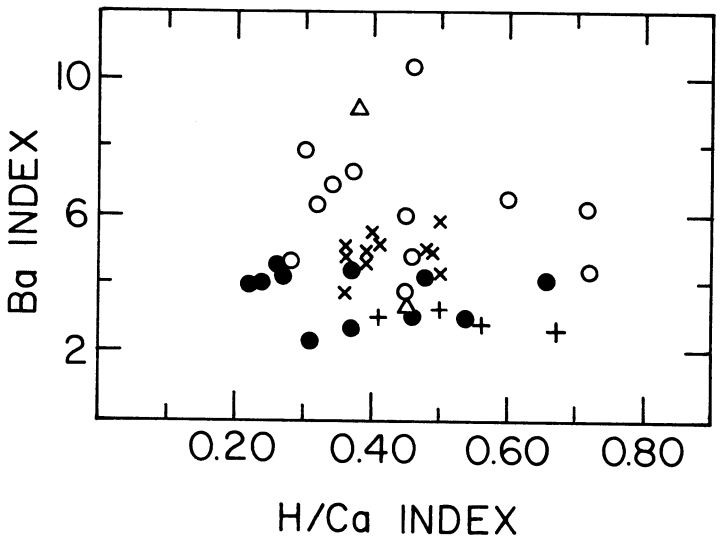

Fig. 1. Barium index vs. H/Ca temperature index. Field stars: normal giants, filled circles; barium stars, open circles. Cluster giants: Praesepe, +'s, NGC 752, X's; NGC 2420, triangles.

Preliminary data for two clump giants in NGC 2420 suggest that one of them (star S) may be enriched in s-process elements and carbon. NGC 2420 contains a previously known barium-carbon star (McClure et al. 1974) at approximately one magnitude brighter than the clump. The overall metal indices suggest that the stars are metal poor, but both stars appear to have enhanced CH. Star S is also enhanced in CN, Sr, and Ba relative to star Q and to the normal field stars. A high carbon abundance may be characteristic of this cluster; NGC 2420 seems prone to produce peculiar stars, but also contains some normal stars. Corroborative observations of star S and others in the clump will be obtained.

Some of these indices can be calibrated using either spectrum synthesis or observations of stars at high dispersion for detailed analysis. The quantitative classification indices will be useful for a variety of purposes besides identifying peculiar stars in clusters. Overall cluster abundances of CH, CN, and Fe group elements can be determined. The barium index is also useful for estimating the mean mass of a clump giant.

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REFERENCES

Cannon, R.D. (1970). Mon. Not. R. Astr. Soc. 150, 111.
McClure, R.D., Forrester, W.T. and Gibson, J. (1974). Astrophys. J. 189, 409.

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