INFRARED PHOTOMETRY OF GLOBULAR CLUSTER GIANT STARS: SOME RECENT RESULTS

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This talk will briefly summarize some recent results based on infrared observations of giant stars in globular clusters. The program is being carried out jointly with Eric Persson and Judith Cohen of the Hale Observatories.

Broad band *JHKL* photometry of cool stars can unambiguously yield bolometric corrections and, with the aid of an appropriate calibration, effective temperatures for these stars. The very recent calibration obtained with lunar occultation data by Kitt Peak astronomers is significantly different from previous calibrations so that, if it is correct, it results in observationally determined giant branch loci that are similar in shape to recently published theoretical loci. (This differs from the statement made in my talk because of the newness of the KPNO results.)

Although the mean CO absorption strength for a given globular cluster shows a general correlation with metallicity, the scatter in the CO strength at a given metallicity is significantly greater than the errors. Previously it was thought that the CO strength might be related to horizontal branch (HB) morphology. Enough clusters have now been observed to show that CO versus HB morphology is a scatter diagram.

Several clusters show significant internal star-to-star scatter in observed CO absorption strength. In at least one cluster, 47 Tucanae, CO and CN absorption strengths exhibit an anticorrelation. Generally, these clusters, except for 47 Tuc, have mean CO strengths that are on the high side for their metallicity, similar to the majority of stars in ω Centauri.

These results will be discussed in detail in several forthcoming publications.

James E. Hesser (ed.), Star Clusters, 435–437.

DISCUSSION

KING: In your correlation of CO against [Fe/H] there were a pair of error bars which you made no reference to, and it seemed to me when looking at the slides that those error bars explained the scatter which you called real.

FROGEL: The CO error bar is the maximum that you can shift the CO for a given cluster and still have that as the mean. The Fe error bar represented the errors in the individual [Fe/H]'s for the clusters; however Zinn feels that on his relative scale the metallicities are much better determined than that error bar.

WALLERSTEIN: Regarding the discrepancy in a cluster like NGC 362: it has a red horizontal branch which means that if the second parameter is the light element abundance the weakness in CO could be due to the fact that the CO line strengths depend on the C x O, while the horizontal branch morphology should depend on the C + N (which isn't important) + O. So it could be that if O is enhanced but C is not enhanced, then the correlation would still hold that the red horizontal branch is due to high light elements, but all concentrated in O; insufficient C to show CO.

FROGEL: That's true. I think the point of that slide, though, is that the CO molecule is not telling you what is going on. You have to look at the individual elements, rather than at the molecule.

DEMARQUE: The discrepancy between the observation and theory for the coolest red giant branch is really not too surprising, because the Sweigert-Gross models were computed using Los Alamos opacities, which do not include molecular opacities. So you'd think that the effect would be most apparent at the cooler end, rather than the other end. When the molecular opacities are available hopefully the agreement will improve.

FROGEL: It will be interesting to see that, but what would be your feeling on having variable mixing-length-to-scale-height ratio?

DEMARQUE: I suppose that's a possibility. There's also the possibility that radiative atmospheres have an effect. We find, for example, that the structure of the radiative part, the $T(\tau)$ relation, in the radiative atmosphere also has a rather marked effect on the calculated radius. So, it may well be that, even if the molecular opacities do not affect the interiors, they might affect the structure of the radiative outer atmosphere in such a way that the boundary conditions are modified.

FROGEL: Well, it'll be interesting to see what you have to do to make the models correspond to the observations.

https://doi.org/10.1017/S0074180900092317 Published online by Cambridge University Press

DEMARQUE: Right.

NEMEC: In regard to the three anomalous globular clusters that stood out in one of your final diagrams, NGC 3201 and M4 in the color-magnitude diagrams of Lee were also a little bit unusual in that the range in luminosity of the red horizontal branch stars was rather broad. In fact, much broader than in any of the other color-magnitude diagrams that he reported.

FROGEL: That is correct and in fact in an infrared color-magnitude diagram the upper part of the NGC 3201 giant branch exhibits the same effect, in the sense that there's a fair amount of spread in effective temperature at a given luminosity. I should say that the most extreme of the CO variations is in NGC 362. By CO variations I mean at a given effective temperature 362 shows the largest star-to-star variation. However, the giant branch itself is quite well defined if you throw out the stars with bad optical photometry. So, there's not necessarily a 1:1 correlation between width in the CO plot and width in the effective temperature-luminosity plot.

RENZINI: Even at the tip of the giant branch you don't see an increase in scatter?

FROGEL: Right, no increased scatter.