CLASSIFICATION OF POPULATION II STARS IN THE *RGU* SYSTEM

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Abstract. The theoretical treatment of the blanketing effect and the first photometric results had shown that the separation of stars of different metal content should be better in the *RGU* system than in the *UBV* system. A three color photometry of the globular cluster M5 is undertaken to show the position of these stars in the *RGU* two-color diagram, to derive the conversion formulae between the two photometric systems for these stars and to use the results for the classification of population II field stars in statistical investigations of the galactic halo.

This work starts from the long known facts that the *RGU*-system allows, other than the *UBV*-system, the separation of late type dwarfs and giants (Becker and Steinlin, 1956) and that the separation of stars with different metal content is better in *RGU* (increased amount of blanketing and greater angle between blanketing lines and main sequence curve in the two-color diagrams) (Smith and Steinlin, 1964). Using the system for Population II stars those advantages, however, may partly be imperiled by the possibility that metal-poor giants might just be moved to the places of metal-rich dwarfs. But altogether *RGU* photometry should be more apt to classify late type stars according to populations. This was the basis for starting an extensive photographic photometry program in high galactic latitude fields in the course of the halo program of the Basel Observatory (Becker, 1965). In this program the densities of Population II stars in different directions in the halo should be determined.

To check the behaviour of Population II stars in the *RGU*-system Palomar Schmidt plates were taken for one of these fields (which contains the globular cluster M5) in the five colors *RGUBV* with limiting magnitude around $19^{m}.5$ in *V*. In M5 a photoelectric and photographic *UBV*-sequence is established (Arp, 1962) and the cluster itself is well known so that the position of the stars in the two-color diagram for *UBV* is reliable. The photometry of cluster and field stars in both three-color systems (the *U*, of course, being common to both) should also provide a set of transformation equations to convert photoelectric *UBV* standards among Population II stars in *RGU* magnitudes for calibration purposes, as they were previously only known for Population I stars (Steinlin, 1968).

At this moment measurements and reductions are not yet finished: only three out of six plates in each color are measured and final corrections for field and scale errors etc. are not yet calculated and applied. The scatter is therefore still large and the results can only be discussed in a qualitative way.

In Figure 1 the two-color diagrams with the main results are given. In *UBV*(left side) the photographic measurements fall into a stripe which is well centered on Arp's cluster sequence (broken line); only for the faintest stars – at the top – the new measurements seem to lie slightly higher, in the sense of a better separation between giant

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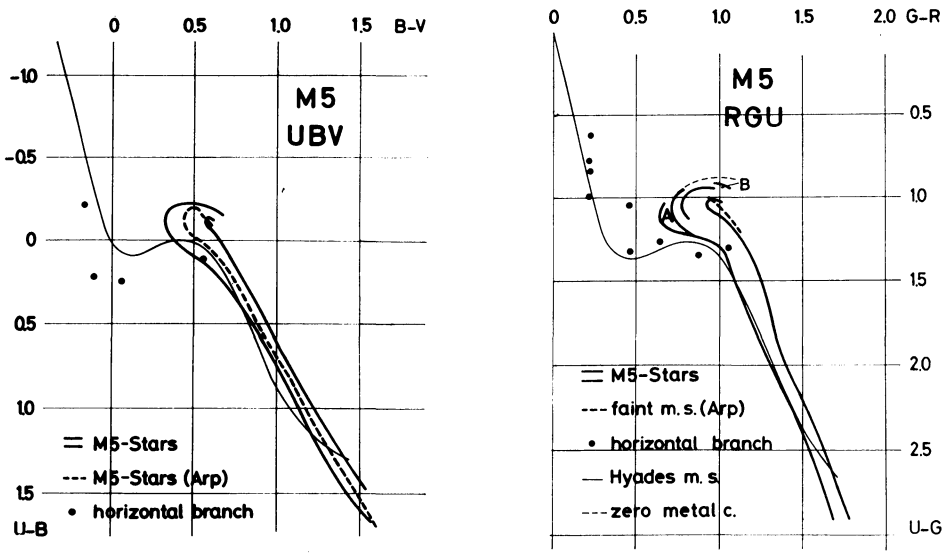

Figs. 1a–b. Two-color diagrams in (a) *UBV* and (b) *RGU* for photographic photometry of the globular cluster M5.

branch and beginning main sequence. But as we reach just at this point the limiting magnitude of the Schmidt plates, not too much weight can be given to this fact. (As the scatter of the individual stars in these diagrams is, in this preliminary stage, still large, no single stars are marked, but only – to obtain a clearer picture – the stripe in which the majority of them falls is indicated.)

In *RGU* (right side) the giant-supergiant branch indeed coincides with the normal (metal-rich) main sequence. But already from $U-G=1.50$ upward the globular cluster stars are well above this curve and permit a neat distinction between them and ordinary field stars. The fainter stars, as expected, turn farther away from the main sequence curve than in the left-hand picture; regarding the normal scatter of photographic magnitudes this difference may be decisive for the possibility of a statistical separation of the two populations. The broken line indicates where the cluster main-sequence stars, assuming the same metal deficiency (as determined in *UBV* by Arp for M5) would lie. As far as one can judge from the fact that only a few uppermost stars of the main sequence are measured in *RGU*, they seem in this diagram as well as in the left one to lie somewhat higher (that is: to show a somewhat lower metal content) than in Arp's paper.

Three groups of stars will need further consideration in the final evaluation. The positions of two of them in the color-magnitude diagram are schematically marked in Figure. 2 (regions A and B). At first glance stars in these regions seem either to be an increasing number of faint field stars or just indicating a large scatter in the color indices. Their mean position is also marked in Figure 1. The group at A is certain'y not a group of Population I field stars in this direction, but definitely a group of

Population II stars. Whether there are halo field stars in this number to be expected can only be judged when the photometry of an adjoining field of about 2000 stars (now under way) will give numbers of stars per square degree at this magnitude range; however it seems more plausible from the number of stars in group A that they are mostly cluster members.

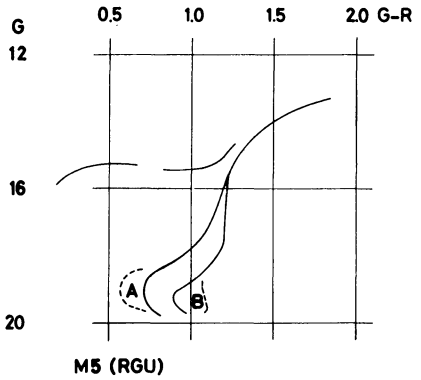

Fig. 2. Color–magnitude diagram of the globular cluster M5 with star groups A and B (schematic).

More surprising is the position of the group B stars in Figure 1. They are definitely at the upper edge of the distribution, that is they seem to indicate a number of cluster stars at the inside of the knee of the cluster diagram with slightly lower metal content than the bulk of the cluster stars.

The third group with unexpected behavior are the horizontal branch stars. In *UBV* they are well below the main sequence curve (confirming Arp's results), but in *RGU* they are right on the main sequence line (each point in Figure 1 represents a mean value of several stars closely together in the cluster color-magnitude diagram). Only a more detailed inspection of the spectral intensity distribution of these stars can show the reason for this behavior.

The conclusions that can be drawn are:

(a) The *RGU* system offers somewhat better possibilities for a statistical separation of stars of the two populations, above all for main sequence stars.

(b) On the other hand is it clear that with this kind of problem the limits of the possibilities of a pure three-color photometry are reached – even more so, when we consider the increased complexity of the diagrams in the case of even only moderate interstellar absorption. This is not surprising, as we are in fact trying to classify the stars in three dimensions (temperature, luminosity, metal content), with interstellar absorption as a possible fourth dimension, with only two independent measured values (color indices). Only in simple and favorable cases this may work; in the present problem we go beyond these limits.

(c) The *RGU* system, however, may give some indications in which direction one may have to look for an additional fourth color to add a new possibility of discrimina-

tion between different groupes. A theoretical approach to this problem is under way at the Basel Observatory.

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