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ANNUAL SUMMARY

REPORT ON CONTRACT Nonr 3403(00)

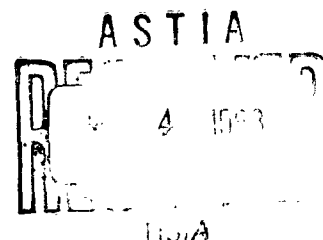
January 11, 1963

"Intrinsic Properties of Giant M Stars, II"

Warner and Swasey Observatory, Case Institute of Technology

Submitted by: Victor M. Blanco, Chief Investigator

To: Geography Branch, Office of Naval Research
Washington 25, D. C.
Attention: Miss Jean Streeter



1. Introduction

The study, reported on here, is a continuation of a study initiated two years ago under the title "Intrinsic Properties of Giant M Stars."

The aims of the project are to:

- (a) Obtain intrinsic color-indices, B-V and V-I, for the giant M stars.
- (b) To determine the variability characteristics of giant M stars.

The method used to study the color indices called for all photometric and spectroscopic observations to be performed, if possible, on the same night. This would permit the spectral classifications and corresponding colors to be found without the errors introduced by the natural variability of the giant M stars. The B and V observations were to be made on the (U, B, V) photometric system, while the I magnitudes were to be obtained in the system of Kron, Gascoigne, and White (Astron. J. 62, 205, 1957). M stars in three distinct areas were to be chosen for the study.

The study of the variability characteristics called for repeated photometric observations of a group of M stars in order to determine for each subclass what percentage is variable and what the statistics of variability are.

As reported at the end of the first year of contract work, color data for 120 M stars found in the surroundings of the clusters M 11, NGC 6709, and NGC 6885 were obtained, and preliminary color indices (B-V) and (V-I) as functions of spectral subclass were derived. Also, 60 M stars of various subclasses were observed photometrically in 40 epochs.

The one-year extension of this research, from February 1, 1962, to January 31, 1963, called for the color study to be carried out in the area SA 158 with photometric and spectroscopic material to be secured at the Bosscha Observatory, Lembang, Java, with the cooperation of Dr. Pik-Sin The. In addition, the variability study was to be extended to M-subtypes earlier than those covered previously and to include another galactic region. The observational material assembled at the Groningen Observatory with the collaboration of Dr. Lukas Plaut was to be used for this purpose.

2. Accomplishments to date

A. Color studies:

(a) The observational material for SA 158 to be collected at the Bosscha Observatory was not received in Cleveland until the fall of 1962. Bad weather delayed the effort, but the observations are now complete. The plates are currently being measured with the astrophotometer and, at the time of writing this report, the analysis of the measurements is also being conducted. During the summer, the undersigned initiated observations from Cleveland of another region near the galactic center to use as an alternate for SA 158 in case the Bosscha observations were not

completed at the desired time. These observations were completed and the plates measured and the desired results obtained.

(b) A great deal of time and effort were spent in eliminating the systematic errors in the color determinations, in finding the interstellar reddening effects, and in obtaining a uniform system of spectral classification in all the areas studied. By using spectral types obtained with the infrared-region criteria developed at this Observatory, the following intrinsic colors are found. This list supercedes the preliminary list submitted in the last annual report.

Spectral Subtype	B-V	n_{B-V}	V-I	n_{V-I}
M0	1.55	13	1.20	13
M1	1.58	20	1.41	31
M2	1.59	16	1.67	29
M3	1.56	16	2.01	26
M4	1.50	20	2.35	29
M5	1.53	21	2.77	33
M6	1.62	17	3.30	30
M7	1.89	6	3.54	15
M8	--	--	4.26	8
M9	--	--	5.30	2
		129		222

The analysis of the photometric material for SA 158, which is being carried out at present, may somewhat alter these results. The above results apply strictly to Case spectral subtypes.

B. Variability characteristics:

(a) The group of M stars, whose magnitudes were determined in 40 epochs during the previous year's work, are found in a region centered at $\ell^{\text{II}} = 4^{\circ}$, $b^{\text{II}} = +10^{\circ}$. During the period of the present contract, this group of stars was increased by the addition of 10 stars of spectral types M0 and M1. In addition, 26 M-type stars in a region centered at $\ell^{\text{II}} = 82^{\circ}$, $b^{\text{II}} = +10^{\circ}$ were observed photometrically in forty epochs. Also, 10 non-variable blue stars were measured in a similar manner in order to obtain comparison standards for deciding what constitutes variability. The measurements for this part of the project were carried out at Groningen, The Netherlands, where Dr. Lukas Plant kindly made available the required plates. All the magnitude determinations were made in the photographic region of the spectrum, and the 40 epochs extended over a 3-year period.

(b) There appear to be no significant differences in variability characteristics in the two areas studied. Hence the material for the two areas was combined for further analysis. After eliminating a few stars whose identification on the plates had proved difficult, a total of 85 M stars was available.

(c) Using the dispersions about the mean found for the constant stars, the M stars were subjected to a variance-ratio test at a 95% level of significance. The results according to spectral class are:

Sp. Class	No. of Stars	% Variables	% Non-Variables
M0	10	40	60
M1	8	88	12
M2	16	88	12
M3	11	73	27
M4	9	100	0
M5	15	87	13
M6	8	50	50
M7	5	80	20
M8	3	100	0

(d) Among the 85 stars studied, only 9 showed definite light curves typical of long-period variables. The rest of the stars, which were suspected of being variable, show irregular variability with a dispersion around a mean of about 0.2 mag. after correction for observational errors. This dispersion was not found to be correlated with the spectral class.

3. Final Remarks

A request by the undersigned is being made, concurrently with this report, for the extension of the contract period for this study, without additional funds, until June 30, 1963. The extension will make it possible to complete the color-index determinations for SA 158 and to prepare and to submit the results of these studies for publication.

Vito M. Blanco

Vito M. Blanco, Chief Investigator