five plates each, in photographic and photovisual wave lengths taken with the 100-inch telescope were measured for magnitudes of selected variables and of those non-variable stars which border the variable star gap. The magnitude system was that used in the previous photometric study of this cluster.¹

The planimetry of the derived light curves, reduced to intensity ratios, yielded mean magnitudes and colors which were the basic data for this investigation. The probable error of an individual measurement was ± 0.025 in m_{pv} and ± 0.027 in m_{pg} . The probable error of the mean magnitude of a given variable is ± 0.01 .

The resulting color-magnitude diagram shows that all the cluster-type variables measured in M 3 fall in a discrete region unoccupied by non-variable stars. There is a sharp delineation between variable stars and non-variable stars. The inclusive region of variability extends from C.I. 0.00 to $+0.23$ with a mean m_{pv} of 15.68. The scatter in magnitude for all save five of the variables is ± 0.03 . These same five stars deviate in relations involving period and amplitude discussed below.

Three stars previously believed to be non-variables fell inside the region occupied by the RR Lyrae stars. These three stars proved to be variables of small amplitude. One star fell on the blue edge of the gap with a period of $0^d.28719$ and an amplitude in m_{pg} of 0.16. The other two stars fell on the red side of the gap with periods $0^d.9170$ and $0^d.9987$ and amplitudes 0.14 and 0.15 mag., respectively.

These three stars are consistent with the general color index-amplitude relation found to hold for all cluster-type variables studied. This relation shows that the amplitude of variation is small at each edge of the variable star region and rises to a maximum of 1.6 in m_{pg} at C.I. = 0.07 mag.

The mean magnitude and color index data have been used to test the pulsation criterion $P\sqrt{\rho} = \text{constant}$. In the observed quantities, this criterion reduces to

$$\log P + .3 m_{pv} = .73 \text{ (C.I.)} \\ - .5 \log (M/M_{\odot}) - 6.28$$

using a pulsation constant of 0.041 days computed by I. Epstein.² A plot of $\log P + .3 m_{pv}$ vs. C.I. gives a linear correlation with slope of .73 for Bailey type *a* and *b* variables as required by theory.

The type *c* variables define a second linear relation with the same slope but with a displacement in period of $P_{a,b}/P_c = 1.48$. This same slope indicates that the type *c* variables satisfy the pulsation criterion. Their displacement in period could indicate pulsation in a different mode from that of the *a* and *b* stars, as suggested by Schwarzschild.³

The period-luminosity relation obtained from this investigation indicates a variation of 0.3 mag. in m_{pg} for a period range of $0^d.3$ to $0^d.7$. Unlike the classical Cepheids, these RR Lyrae stars are brighter at shorter periods and fainter at the long periods. In m_{pv} there is no significant change of magnitude with period.

1. *A. J.* 58, 61, 1953.

2. *Ap. J.* 112, 6, 1950.

3. *Circ. Harv. Coll. Obs.* No. 437, 1940.

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Rush, J. H. and Dorothy E. Trotter. Evidence of the 23-year solar cycle in recurrent magnetic storms.

Magnetic storms recurring at 27-day intervals were more than twice as numerous before the sunspot minima of 1913 and 1933 as they were before the intervening minima of 1923 and 1944. For these two sets of minima we found totals of 113 and 49 individual storms, respectively, counting storms in dubious sequences at half-weight. A conventional statistical criterion applied to these data yields a probability of about 0.14 that the observed difference is due to chance.¹

This evidence suggests that recurrent storm activity regularly alternates between high and low values in successive spot cycles. On this supposition, the incidence of recurrent storms during the current minimum should be high. To date, 45 such storms have occurred, on the same basis of weighting as was applied to the earlier sets. This figure exceeds the mean for the preceding four minima; and recurrent storm sequences have not yet ceased.

In terms of Wolf numbers, sunspot activity during the four cycles ending 1913-1944 has alternated between relatively high and low values, but in opposite phase to the recurrent storm activity. This fact might suggest that the alternation in numbers of recurrent storms results from an inverse dependence of M-region activity on spot numbers; but spot numbers during the

cycle just ending have been the greatest since 1870. Another interesting possibility is that the alternation in recurrent storm activity is related to the 23-year magnetic cycle of the sun. If the spot fields are related to an alternating general field with a period corresponding to the double spot cycle, as proposed by Grotian² and Babcock,³ or to large-scale toroidal fields of similar period, as Richardson and Schwarzschild have suggested,⁴ then the dissymmetry of such a field with respect to the 11-year cycle may influence the formation and persistence of M regions. Further, the interaction of large-scale solar fields with the earth's field may influence the propagation of solar particle streams into the earth's atmosphere in such a way as to produce a dissymmetry in the incidence of recurrent magnetic storms during alternate sunspot periods.

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1. Croxton and Cowden, *Applied General Statistics*, p. 317 ff., 1941.
2. *Naturwissenschaften* 7, 163, 1950.
3. *Nature* 166, 249, 1950.
4. *Acad. Naz. Lincei, Convegno Volta*, No. 11, Sept. 1953.

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Savedoff, Malcolm P. Color magnitude array of M 13.

A color magnitude array based on 1400 stars in the globular cluster M 13 was obtained from plates taken with the Hale reflector at Mount Palomar by W. Baade. Unblended images were chosen for measurement by comparison of one-minute, three-minute, and thirty-minute photovisual exposures. This criterion introduces a selection against the brighter stars, but does not affect the distribution in color of stars of the same visual magnitude.

The diagram presented is based on measures of four IIA-O plates with GG1 filter and four 103a-D plates with GG11 filter, all three-minute exposures, and all taken within a period of less than two hours. These plates were measured on the Eichner astrophotometer at the California Institute of Technology. The photometer readings were converted to the photoelectric system of W. Baum by interpolating between the unpublished measures by Baum and H. L. Johnson of 15 and 42 stars, respectively.

The principal result of this investigation is that the array for M 13 differs appreciably from that

for M 3 and M 92. In addition, the blue extension of the cluster-variable branch extends past the eighteenth magnitude photovisual. It should be noted that color standards for very blue stars are not sufficient for detailed intercomparison.

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Schopp, John D. Determination of upper limits to the abundance of carbon 13 in normal red giant stars.

High dispersion spectra (10 Å/mm) of 28 stars were taken at the coudé focus of the Mt. Wilson 100-inch. The program included 20 stars of luminosity class III normal red giants, and 8 stars of luminosity classes IV, III-IV, II-III, and II, all 28 being in the spectral range G8 to K5. Tracings of these spectra were measured to determine upper limits to the abundance of carbon 13 in their atmospheres.

Pseudo curves of growth were obtained from depth measures on 25 FeI lines in the region $\lambda 4000$ to $\lambda 4100$, and from relative stellar log X values for these lines. The log X values were derived from solar log X values, given by Barbara Bell,¹ by means of effective temperature obtained from photoelectric colors measured at the Princeton 23-inch. The colors were tied to the Johnson system.²

By comparing computed and measured strengths of absorption lines in the ultraviolet (0, 0) band of $C^{12}N^{14}$ near $\lambda 3883$, and predicted lines in the isotopic band, $C^{13}N^{14}$, lower limits on the ratio C^{12}/C^{13} were obtained. For the 15 stars in the spectral group G8 to K1 this ratio ranged from 23 to 7, while for the stars K2 to K5 the ratio ran from 15 to 0.6. Low ratios in the second group can probably be attributed to the fact that the strength of the CN band falls off considerably thus making the test insensitive. The results for stars of the first group are probably significant enough, however, to warrant the conclusion that carbon 13 is not present in the atmospheres by as much as one part in four. Since an equilibrium ratio of C^{12}/C^{13} of the order of three is predicted for carbon involved in the carbon-nitrogen cycle, we may say that if these stars have ever generated energy in this way, there has been no appreciable mixing between the core and the atmosphere. It may be recalled that McKellar found carbon 13 abundant by one part in four in several R-type stars.³

In addition it was found that CN reaches maximum strength at about K0 or K1 in normal giants.