

ΑΣΤΡΟΝΟΜΙΑ.— **Very Red Objects on the Palomar Observatory Sky Survey**, by *C. Poulakos**. Ἀνεκοινώθη ὑπὸ τοῦ Ἀκαδημαϊκοῦ κ. Ι. Ξανθάκη.

S U M M A R Y

We report the discovery of 22 extraordinarily red stars having $B - V \geq 4.0$ mag. found on the Palomar Observatory Sky Survey charts. Besides, three new peculiar objects have been found. Positions, magnitudes and colour indices of the 22 objects are given.

I N T R O D U C T I O N

The main purpose of the present investigation was the identification of extremely red stars and, due to the fast growing importance of the infrared objects in the last years, to provide the northern observers with lists of particularly interesting objects.

The present paper reports the discovery of 22 infrared stars identified in an area of about 230 sq deg at $l = 113^\circ$, $-10^\circ \leq b \leq +90^\circ$ on the POSS charts. Besides, three new peculiar objects have been found. Seven of these stars are already known to be intrinsically red than being reddened stars. Another three stars are included in the 2 μ Survey (Neugebauer and Leighton, 1969) but no evidence about their extreme redness was previously known due to the absence of spectral classification.

METHODS OF SEARCH AND MEASUREMENTS

In all 100 fields, having generous overlap, of about 2.3 sq deg each were searched. The fields are distributed along a strip extending perpendicular to the galactic equator at $l = 113^\circ$.

The searching procedure was done by use of transparent reproductions of the red and the blue POSS charts. Positive transparencies showing the objects dark on a bright background were made from the red POSS charts. Each pair of the transparencies had the same scale i. e.

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three times larger than the original POSS plates. Superposing the negative and the positive transparencies of each field and illuminating them from below the outstanding red stars appeared as bright holes or bright rings. Every field was searched independently twice.

In the present investigation extremely red star is regarded a star having a colour index $B - V \geq 4.0$ mag. Hence during the search all objects having the red diameter at least four to five times larger than the blue ones were considered as suspected very red stars and were examined separately.

Since the limiting magnitude of the POSS charts is $b = 21.0$ mag. only stars having $r \leq 15.0$ mag. come into question. B (blue) and r (red) magnitudes for all the stars determined by measurements of the diameter on the blue and the red plates as suggested by Perek (1958). The process of measurements was similar to that of Ackermann's (1970). For calibration the magnitude-diameter relation given by Dorschner et al. (1966) was used. The colour index $B - V$ was determined with the help of the relation

$$b - r = 1.49 (B - V)$$

given by Dorschner et al. (1966).

The probable error of an adopted magnitude estimated by this method is of the order of 0.3 magnitudes.

RESULTS AND DISCUSSION

On the transparencies the search has led to the selection of 280 starlike objects which, due to their remarkable redness, attracted our attention. 138 of them turned out to be photographic defects of stellar appearance, when examined on the POSS charts. The criterion to decide whether a starlike object is simply a plate defect is based upon one or several main reasons which we described elsewhere (Weinberger and Poulakos, 1977). The remaining 142 objects are undoubtedly stars.

Out of these 142 stars only 22 fulfilled the required selection criterion of $B - V \geq 4^m0$.

Finding charts for the 22 extremely red stars, reproduced from the POSS charts, are given in fig. 1. In fig. 1 north is up east is to the left. All charts have the same scale.

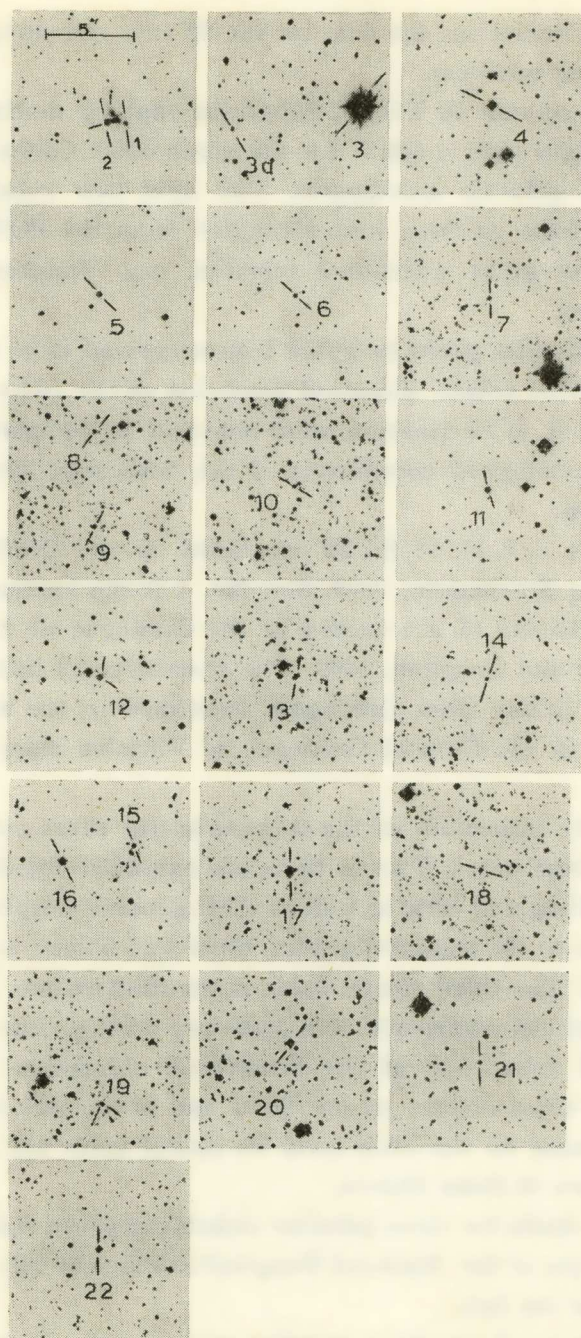


Fig. 1. Finding charts for objects 1 to 22, reproduced from the red POSS prints. North is up, east is to the left. All charts have the same scale.

Table 1 summarizes the data for the 22 very red stars to which are assigned running numbers.

The first column in Table 1 gives the running number the second and third columns give α and δ for the epoch 1950. Columns fourth and fifth give the galactic coordinates. The next two columns give the photometric results as these were estimated from the POSS charts and the last column gives additional remarks, e.g. designations used in other catalogues.

The coordinates given in Table 1 were derived from measurements made on the POSS prints. Standard deviation of the order of $\pm 0^m.2$ in R. A. and $\pm 1'.6$ in Declination were obtained by comparing the measured and the catalogued coordinates of the SAO stars lying within the surveyed region.

Stars Nos. 3, 7, 17, 18, 20, 22 are listed in the Catalogue of Cool Carbon stars by Stephenson, 1973. Star No. 4 is the known variable AM Cep. Nos. 12, 15 and 16 are quoted in the Catalogue of 2μ sky Survey by Neugebauer and Leighton, 1969. The remainder 12 infrared stars are not contained in any other Catalogues examined by the writer, nor are they included in the General Catalogue of Variable stars by Kukarkin et al., 1972.

During the inspection of the transparencies three peculiar objects of red colour were noted. Two of them are extended objects of elliptical shape. Their elongated form as well as their general morphological characteristics lead to the assumption that these two objects are galaxies of elliptical type. The third object which is the faintest one, has the shape and the general characteristics of a planetary nebula. Due to the appreciable lack of knowledge of the foreground absorption in the line of sight of these three objects on one hand and to the lack of appreciable surface brightness on the other hand we cannot make any final decision about the nature of these objects.

Finding charts for these peculiar objects are given in figure 2 which are enlargements of the National Geographic Palomar Sky Atlas. North is up east is to the left.

Coincidences of the three peculiar objects with objects listed in the various lists and Catalogues of galaxies, planetary nebulae, and radio sources have not been found. This is perhaps reasonable because these

Extremely red stars with $B - V \geq 4.0$

| Star No. | α (1950) | δ (1950) | I^H | b^H | r (mag) | $B - V$ (mag) | Remarks |
|----------|--|-----------------|--------|---------|-----------|---------------|-----------------------------------|
| 1 | 21 ^h 00 ^m 41 ^s .7 | + 78° 11'.5 | 112.43 | + 20.59 | 14.40 | 4.43 | |
| 2 | 21 00 41.7 | + 78 11.6 | 112.43 | + 20.59 | 13.80 | 4.09 | |
| 3 | 21 35 54.0 | + 78 24.1 | 113.80 | + 19.40 | > 8.0 | > 4.00 | S Cep., No. 3055 Stephenson, 1973 |
| 4 | 21 41 34.0 | + 76 09.7 | 112.44 | + 17.55 | 9.10 | 4.77 | AM Cep. |
| 5 | 21 58 52.2 | + 76 34.2 | 113.54 | + 17.19 | 11.20 | 5.17 | |
| 6 | 22 59 26.4 | + 67 52.0 | 112.94 | + 7.43 | 12.00 | 6.04 | |
| 7 | 23 08 02.2 | + 65 02.1 | 112.59 | + 4.49 | 12.80 | 5.84 | No. 3179 Stephenson, 1973 |
| 8 | 23 08 45.1 | + 64 39.1 | 112.53 | + 4.10 | 12.10 | 5.97 | |
| 9 | 23 08 52.2 | + 64 33.8 | 112.51 | + 4.02 | 13.45 | 5.07 | |
| 10 | 23 13 18.3 | + 64 13.2 | 112.82 | + 3.52 | 13.60 | 4.97 | |
| 11 | 23 13 47.4 | + 67 31.5 | 114.07 | + 6.60 | 10.60 | 4.56 | |
| 12 | 23 13 49.4 | + 62 05.3 | 112.11 | + 1.51 | 10.00 | 4.30 | No. + 60° 393 2 μ Survey |
| 13 | 23 16 45.5 | + 65 25.1 | 113.60 | + 5.35 | 13.00 | > 5.37 | |
| 14 | 23 20 38.0 | + 62 35.4 | 113.02 | + 1.71 | 12.20 | 4.03 | No. + 60° 409 2 μ Survey |
| 15 | 23 27 42.2 | + 60 00.3 | 113.00 | - 1.02 | 11.00 | 4.33 | No. + 60° 411 2 μ Survey |
| 16 | 23 28 15.9 | + 59 58.3 | 113.06 | - 1.07 | 8.50 | 4.09 | |
| 17 | 23 29 54.3 | + 61 49.9 | 113.81 | + 0.65 | 8.30 | 5.03 | DS Cas, No. 3190 Stephenson, 1973 |
| 18 | 23 34 39.3 | + 57 10.3 | 113.03 | - 3.99 | 12.90 | 4.40 | DU Cas, No. 3192 Stephenson, 1973 |
| 19 | 23 34 56.9 | + 59 31.6 | 113.74 | - 1.73 | 13.80 | 4.15 | |
| 20 | 23 35 41.2 | + 55 45.8 | 112.76 | - 5.37 | 10.20 | 4.23 | LS Cas, No. 3193 Stephenson, 1973 |
| 21 | 23 36 35.4 | + 58 37.4 | 113.68 | - 2.67 | 12.50 | 4.03 | |
| 22 | 23 36 58.8 | + 59 17.8 | 113.92 | - 2.03 | 8.90 | 4.26 | DX Cas, No. 3197 Stephenson, 1973 |

objects have on the charts low surface brightness and therefore too faint to have been discovered on the earlier visual or photographic surveys.

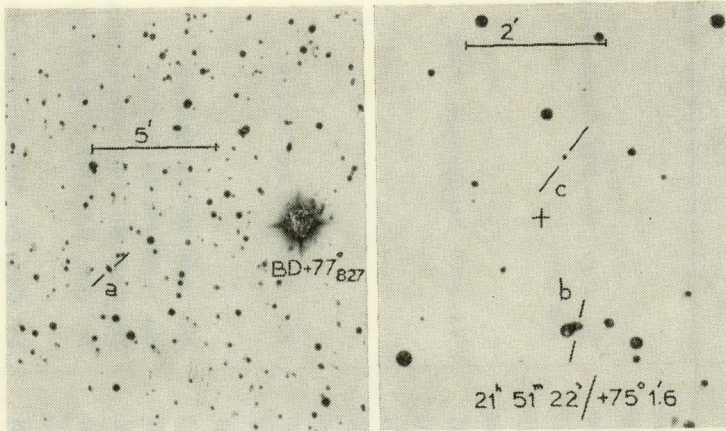


Fig. 2. Finding charts for the three peculiar objects a, b and c, reproduced from the red POSS prints. North is up east is to the left. At the bottom of each chart the α and δ for the epoch 1950 are marked.

The relation b versus $(B - V)$ for the 22 infrared stars is shown in fig. 3.

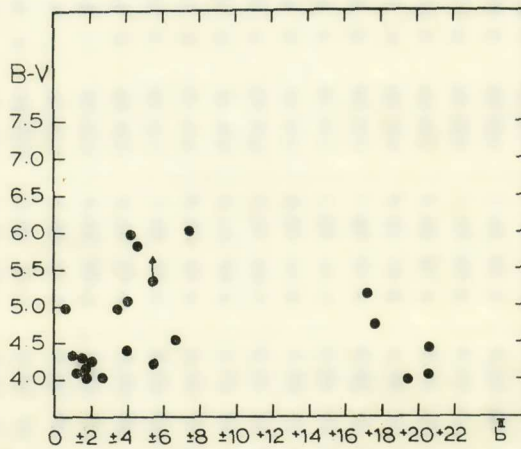


Fig. 3. Galactic latitude versus colour index $(B - V)$ for the 22 infrared stars.

Π Ε Ρ Ι Λ Η Ψ Ι Σ

Τὸ κατὰ τὰ τελευταῖα ἔτη διαρκῶς αὐξανόμενον ἐνδιαφέρον τῶν ἐρευνητῶν διὰ τὴν μελέτην τῶν λίαν ἐρυθρῶν ἀστέρων ὑπῆρξεν ἡ ἀφορμὴ διὰ τὴν ἔρευναν τὴν ἐκτεθειμένην εἰς τὴν παροῦσαν ἐργασίαν. Σκοπὸς τῆς ἐρεύνης ταύτης εἶναι ἡ ἀνακάλυψις ὑπερύθρων ἀντικειμένων δηλ. ἀντικειμένων ἐχόντων $B - V \geq 4.0$ τὰ ὁποῖα θὰ χρησιμεύσουν ὡς ἀντικείμενον ἰδιαίτερας μελέτης ὑπὸ τῶν διαφόρων ἐρευνητῶν.

Ὡς ὑλικὸν παρατηρήσεως ἐχρησιμοποιήθη ὁ Ἄτλας τοῦ Ἀστεροσκοπεῖου τοῦ Πάλομαρ.

Ἐκ τῆς γενομένης ἐρεύνης ἀνευρέθησαν 22 ἀστέρες πληροῦντες τὸ θεσπισθὲν κριτήριον $B - V \geq 4.0$. Ἐξ αὐτῶν 7 ἀστέρες εὐρέθησαν ἤδη καταγεγραμμένοι εἰς καταλόγους λίαν ἐρυθρῶν ἀστέρων, ἐνῶ ἕτεροι 3 ἀστέρες εὐρέθησαν καταγεγραμμένοι εἰς τὸν ὑπὸ τῶν Neugebauer καὶ Leighton συνταχθέντα κατάλογον ἀντικειμένων ἐχόντων ἔντονη ἐκπομπὴν εἰς τὰ 20.000 Å.

Οἱ ἀπομένοντες 12 ἀστέρες εἶναι νέοι ἀστέρες μὴ καταγεγραμμένοι εἰς ἐτέρους καταλόγους.

Τὸ γεγονός ὅτι 10 ἐκ τῶν ἀνευρεθέντων ἀστέρων εἶναι γνωστοὶ ὑπερύθροι ἀστέρες συνηγορεῖ ὑπὲρ τοῦ νὰ ὑποθέσῃ τις ὅτι διὰ τοῦ θεσπισθέντος κριτηρίου, ἐπιλογῆς ὑπερύθρων ἀντικειμένων ἀνευρέθησαν μόνον οἱ λίαν ἐρυθροὶ ἀστέρες καὶ μόνον αὐτοί.

R E F E R E N C E S

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Ὁ Ἀκαδημαϊκὸς κ. **Ι. Ξανθάκης**, παρουσιάζων τὴν ἀνωτέρω ἀνακοίνωσιν, εἶπε τὰ ἑξῆς :

Σκοπὸς τῆς ἐρεῦνης ταύτης τοῦ Ἐπιμελητοῦ τοῦ Κέντρου Ἑρευνῶν Ἀστρονομίας κ. Κων/νου Πουλάκου εἶναι ἡ ἀνακάλυψις ὑπερύθρων ἀντικειμένων δηλ. ἀντικειμένων ποὺ νὰ ἔχουν διαφορὰν χρώματος μεταξὺ κυανοῦ καὶ κιτρίνου φωτὸς μεγαλύτερον ἀπὸ 4 ἀστρικά μεγέθη.

Ὁ κ. Πουλάκος ἐχρησιμοποίησεν ὥς ὕλικὸν παρατηρήσεως τὶς φωτογραφικὰς πλάκες τοῦ Ἀστεροσκοπείου τοῦ Πάλομαρ.

Εἰς τὰ 12 δὲ ζεύγη πλακῶν ποὺ καλύπτουν συνολικὸν ἐμβαδὸν 230 τετραγωνικὰς μοῖρας, ἐξητάσθησαν ἐπισταμένως καὶ ἀνευρέθησαν 22 ἀστέρες ποὺ πληροῦν τὸ ἀνωτέρω κριτήριον τοῦ δείκτου χρώματος. Ἐξ αὐτῶν οἱ 7 ἀστέρες εὐρέθησαν καταγεγραμμένοι εἰς τοὺς καταλόγους λίαν ἐρυθρῶν ἀστέρων ἐνῶ ἄλλοι 3 εὐρέθησαν καταγεγραμμένοι εἰς τὸν ὑπὸ τῶν Leighton καὶ Neugebauer συνταχθέντα κατάλογον ἀστέρων μὲ ἔντονον ἀκτινοβολίαν εἰς τὰ 20.000 Å. Οἱ ὑπόλοιποι 12 ἀστέρες ἀποκαλύπτονται τὸ πρῶτον ὥς ὑπερύθρα ἀντικείμενα μὴ καταγεγραμμένα εἰς τοὺς σχετικὸς καταλόγους.

Τὸ γεγονός ὅτι οἱ 10 ἐκ τῶν 22 ἀνευρεθέντων ἀστέρων εἶναι γνωστοὶ ὑπερύθροι ἀστέρες συνηγορεῖ ὑπὲρ τῆς παραδοχῆς ὅτι διὰ τοῦ θεσπισθέντος κριτηρίου ἐπιλογῆς ὑπερύθρων ἀστέρων ἀνευρέθησαν μόνον οἱ λίαν ἐρυθροὶ ἀστέρες καὶ μόνον αὐτοί.