PHOTOMETRY AND CLASSIFICATION OF STARS AROUND THE REFLECTION NEBULA NGC 7023 IN CEPHEUS. II. INTERSTELLAR EXTINCTION AND CLOUD DISTANCES

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Abstract. Interstellar extinction is investigated in a 1.5 square degree area in the direction of the reflection nebula NGC 7023 at $\ell = 104.1^\circ$, $b = +14.2^\circ$. The study is based on photometric classification and the determination of interstellar extinctions and distances of 480 stars down to $V = 16.5$ mag from photometry in the Vilnius seven-color system published in Paper I (2008). The investigated area is divided into five smaller subareas with slightly different dependence of the extinction on distance. The distribution of reddened stars is in accordance with the presence of two dust clouds at 282 pc and 715 pc, however in some directions the dust distribution can be continuous or more clouds can be present.

Key words: stars: fundamental parameters, classification – Galaxy: Cepheus Flare, NGC 7023 – ISM: extinction, clouds: individual (TGU 629)

1. INTRODUCTION

The distances to star-forming regions in the Cepheus Flare, an out-of-plane concentration of interstellar dust and molecular clouds, are still unknown to sufficient accuracy, see the recent review by Kun et al. (2008). This our investigation is an attempt to determine more reliable distances and extinctions of dust clouds in the direction of the reflection nebula NGC 7023, illuminated by the young high-mass star HD 200775 and surrounded by the dust cloud TGU 629 (Dobashi et al. 2005).

In our earlier paper (Zdanavičius et al. 2008, hereafter Paper I) we determined in this area the magnitudes and color indices in the Vilnius seven-color photometric system for 1240 stars down to $V \approx 16.7$ mag. The published catalog for most of the stars also contains two-dimensional spectral types determined by interstellar reddening-free methods from the multicolor photometric data.

In the present paper we apply the classification results of Paper I for determining the distribution of the interstellar dust with distance in the 1.5 square degree area around the NGC 7023 nebula, using only the selected stars with the most reliable spectral types. In Section 2, we describe the classification methods based on the interstellar reddening-free parameters, used for determining the spectral types, and calculate interstellar redenings and extinctions of the stars. The distribution
of interstellar dust in the area is investigated in Section 3 and the discussion and summary of the results are given in Section 4.

2. TWO-DIMENSIONAL PHOTOMETRIC CLASSIFICATION

For the classification of stars a few different codes using slightly different spectral standards were used.

1. COMPAR code is based on the \( \sigma Q \) method described by Straižys et al. (1992, 2002). The method uses matching 14 different interstellar reddening-free \( Q \)-parameters of a program star to those of about 8400 standard stars of various spectral and luminosity classes, metallicities and peculiarity types. The results of the classification are spectral and luminosity classes and the indication of peculiarity. Several varieties of the code and sets of standards were used.

2. xqKLAS code uses the xq-method described by Zdanavičius (2005). The method is based on a new concept of reddening-free parameters (\( q \)) and a ‘virtual’ quantity of the interstellar dust (\( x \)). 1418 standards were formed by calculating the mean dereddened color indices for 89 spectral subclasses (in most cases, for each one subclass and for late-type stars for each 0.25 subclass) and the 17 values of the absolute magnitude, \( M_V \). The results of the classification are spectral class and absolute magnitude.

3. TINKLAS code classifies stars using six \( Q_Q \) diagrams described in Straižys (1992) monograph. Each of them is formed from two reddening-free \( Q \)-parameters and calibrated in terms of spectral classes and absolute magnitudes. The results are spectral class and absolute magnitude.

Spectral classes and absolute magnitudes of stars determined by the methods (2) and (3) were used to estimate their luminosity classes taking the calibration of MK spectral types in absolute magnitudes from Straižys (1992). Then the spectral and luminosity classes determined by the three methods for each star were weighted and averaged. The intrinsic color indices used in determining the interstellar extinction and the distance are also taken from Straižys (1992).

As it was stated in Paper I, the \( J–H \) and \( H–K_s \) color indices from the 2MASS survey (Cutri et al. 2003; Skrutskie et al. 2006) in some cases were helpful for the identification of K and M dwarfs.

3. INTERSTELLAR EXTINCTIONS AND DISTANCES

The interstellar redenings \( E_{Y-V} \) of 480 stars with the most reliable classification were determined as differences between the observed color indices \( Y–V \) given in Table 2 of Paper I and the intrinsic color indices \( (Y-V)_0 \) for a given spectral type taken from Tables 67–69 of the Straižys (1992) monograph. Color excesses were transformed to extinctions by the equation \( A_V = 4.16 E_{Y-V} \). Distances \( d \) to the stars in parsecs were calculated by the equation \( 5 \log d = V - M_V + 5 - A_V \). Here \( V \) are from Paper I and \( M_V \) are from the tabulation given in Straižys (1992, Appendix I), adjusted to a Hyades distance modulus of 3.3 mag. The results are given in Table 1 which gives the star number in the catalog of Paper I, \( V \) magnitude, spectral type and its quality, absolute magnitude \( M_V \), interstellar extinction \( A_V \), distance \( d \) and the name of the subarea to which the star is attributed. The subareas are described lower in this section and are shown in Figure 2.
Table 1. Stars in the investigated area with most reliable spectral types determined from Vilnius photometry. The column $p$ gives the accuracy estimates of spectral types.

| No. | $V$   | Sp  | $p$ | $M_V$ | $A_V$ | $d$ (pc) | Subarea |
|-----|-------|-----|-----|-------|-------|----------|---------|
| 5   | 15.75 | g2.5 V | 1.0 | 4.59  | 1.36  | 910      | I       |
| 6   | 12.91 | g8 III | 1.0 | 0.78  | 1.25  | 1500     | I       |
| 11  | 15.77 | f6 V   | 0.9 | 3.73  | 1.13  | 1520     | I       |
| 12  | 15.39 | f5 III | 0.9 | 1.79  | 1.07  | 3200     | I       |
| 14  | 15.70 | k0.5 V | 0.8 | 5.95  | 1.31  | 488      | I       |
| 15  | 14.56 | g0 IV  | 0.9 | 3.10  | 1.09  | 1190     | I       |
| 16  | 15.29 | g1 V   | 0.8 | 4.76  | 1.14  | 760      | I       |
| 23  | 15.70 | g7 V   | 1.0 | 5.40  | 1.00  | 720      | I       |
| 33  | 13.70 | f7 IV  | 0.9 | 2.10  | 1.11  | 1250     | I       |
| 34  | 11.75 | f8 V   | 0.9 | 3.84  | 0.24  | 342      | I       |
| 40  | 15.62 | g5.5 V | 1.0 | 4.91  | 1.73  | 630      | I       |
| 47  | 15.84 | g2.5 V | 0.8 | 4.85  | 1.18  | 920      | I       |
| 50  | 15.56 | g2 V   | 1.0 | 4.47  | 0.79  | 289      | I       |
| 51  | 14.98 | f8 IV  | 0.9 | 2.40  | 1.13  | 1950     | I       |
| 53  | 13.65 | f1 III | 0.9 | 1.20  | 1.20  | 1780     | I       |
| 54  | 15.41 | g9 III | 0.8 | 1.35  | 1.18  | 3760     | I       |
| 56  | 15.68 | g8 III | 0.8 | 0.61  | 2.03  | 4060     |         |
| 57  | 15.90 | g7 V   | 1.0 | 5.24  | 1.12  | 810      |         |
| 63  | 14.33 | k0 III | 1.0 | 0.50  | 1.49  | 2950     | IV      |
| 68  | 13.91 | g8 V   | 1.0 | 5.35  | 0.84  | 350      | I       |
| 71  | 15.26 | f8 IV  | 0.9 | 2.22  | 1.14  | 2390     | I       |
| 72  | 16.62 | f7 V   | 0.7 | 4.07  | 1.16  | 1900     | I       |
| 75  | 9.71  | f5 IV  | 0.9 | 2.71  | 0.09  | 241      | IV      |
| 76  | 12.40 | f3 V   | 0.9 | 3.16  | 0.74  | 500      | I       |
| 79  | 11.69 | g1 V   | 0.8 | 4.59  | 0.00  | 263      | I       |
| 82  | 15.19 | g4 V   | 1.0 | 4.71  | 1.00  | 790      | I       |
| 83  | 14.49 | g1.5 V | 1.0 | 4.48  | 0.41  | 830      | I       |
| 84  | 13.90 | f8 IV  | 0.9 | 1.96  | 1.51  | 1220     | IV      |
| 86  | 15.59 | f5 V   | 0.9 | 3.56  | 0.99  | 1610     | I       |
| 87  | 13.38 | g9.5 III | 1.0 | 0.75  | 1.18  | 1950     | I       |
| 88  | 14.39 | f4 V   | 0.9 | 3.40  | 1.09  | 960      | I       |
| 89  | 10.15 | f3 V   | 0.9 | 3.24  | 0.01  | 240      | I       |
| 101 | 13.82 | g8 III | 1.0 | 1.59  | 1.54  | 1370     | IV      |
| 103 | 12.42 | k2 III | 1.0 | 0.70  | 1.05  | 1360     | I       |
| 104 | 12.38 | f4 III | 0.9 | 1.96  | 1.31  | 660      | IV      |
| 105 | 13.13 | k1 IV  | 1.0 | 3.11  | 1.15  | 590      | I       |
| 108 | 15.80 | g3 V   | 0.8 | 4.87  | 1.06  | 940      | I       |
| 110 | 15.71 | g1.5 V | 0.8 | 4.45  | 1.22  | 1020     | I       |
| 117 | 15.19 | g9.5 III | 0.8 | 0.70  | 1.85  | 3380     | IV      |
| 125 | 16.08 | k1.5 V | 0.7 | 6.37  | 0.86  | 590      | I       |
| 126 | 14.99 | f5 V   | 0.9 | 3.64  | 1.11  | 1120     | I       |
| 134 | 14.69 | f5 IV  | 0.9 | 2.23  | 1.66  | 1450     | IV      |
| 135 | 14.59 | g9 IV  | 1.0 | 2.64  | 1.48  | 1240     | IV      |
| 136 | 14.63 | k1.2 V | 1.0 | 5.46  | 0.92  | 447      | I       |
| 138 | 16.42 | g3 IV  | 0.7 | 2.89  | 1.16  | 2980     | I       |
Table 1. Continued

| No. | $V$  | Sp    | $p$ | $M_V$ | $A_V$ | $d$ (pc) | Subarea |
|-----|------|-------|-----|-------|-------|----------|---------|
| 141 | 16.15| g1.5 IV | 0.7 | 3.09  | 1.50  | 2040     | I       |
| 143 | 15.41| k1 IV  | 0.8 | 3.64  | 1.38  | 1190     | I       |
| 144 | 16.18| g3 IV  | 0.7 | 3.44  | 1.60  | 1690     | IV      |
| 147 | 15.52| g8 V   | 1.0 | 5.01  | 1.19  | 730      | IV      |
| 149 | 16.07| k0.5 IV | 0.8 | 3.19  | 1.16  | 2210     | I       |
| 150 | 14.98| k0.5 V  | 1.0 | 5.84  | 0.56  | 520      | I       |
| 153 | 13.03| k3.5 III | 1.0 | 0.48  | 1.07  | 1980     | I       |
| 158 | 15.96| g9.5 IV | 0.8 | 2.75  | 1.26  | 2450     | I       |
| 160 | 14.45| a5 IV  | 0.9 | 1.24  | 1.78  | 1930     | IV      |
| 161 | 11.60| g8 III | 1.0 | 0.83  | 1.50  | 710      | I       |
| 162 | 15.04| k0.5 V  | 1.0 | 5.63  | 0.79  | 530      | I       |
| 168 | 13.30| g9.5 III | 1.0 | 0.54  | 2.13  | 1340     | IV      |
| 174 | 15.54| f6 IV  | 0.9 | 2.62  | 1.63  | 1820     | I       |
| 176 | 16.14| g1 V   | 0.8 | 4.56  | 0.83  | 1410     | I       |
| 177 | 15.61| g3 V   | 0.8 | 4.80  | 1.50  | 730      | I       |
| 178 | 14.98| k0.5 IV | 0.8 | 2.77  | 1.10  | 1660     | I       |
| 179 | 13.79| f6 IV  | 0.9 | 2.85  | 1.27  | 860      | IV      |
| 181 | 15.93| g2 V   | 0.8 | 4.70  | 1.29  | 970      | I       |
| 182 | 13.11| g9 III | 1.0 | 0.73  | 1.65  | 1400     | IV      |
| 184 | 15.09| g1.5 IV | 1.0 | 3.23  | 1.21  | 1340     | I       |
| 185 | 15.32| k0 III | 0.8 | 1.08  | 1.58  | 3400     | IV      |
| 188 | 15.09| k3.2 III | 0.8 | 0.73  | 1.25  | 4170     |        |
| 190 | 9.80 | k3 III | 1.0 | 0.29  | 1.62  | 720      | I       |
| 194 | 11.56| g3 V   | 1.0 | 4.82  | 0.15  | 209      | IV      |
| 199 | 15.45| g1 IV  | 0.7 | 3.02  | 1.85  | 1310     | IV      |
| 200 | 12.78| k0.7 III | 1.0 | 0.79  | 1.67  | 1150     | IV      |
| 202 | 15.58| g7 V   | 1.0 | 5.47  | 1.23  | 600      | I       |
| 204 | 15.22| g0 V   | 1.0 | 4.00  | 1.45  | 900      | IV      |
| 205 | 14.52| g3 V   | 1.0 | 4.87  | 1.08  | 520      | I       |
| 207 | 13.08| g0 IV  | 0.9 | 2.54  | 0.97  | 820      | IV      |
| 208 | 15.67| k1 IV  | 0.8 | 3.66  | 1.34  | 1370     | IV      |
| 209 | 14.36| g3 V   | 1.0 | 4.86  | 0.86  | 530      | I       |
| 215 | 12.61| f3 IV  | 0.9 | 2.54  | 0.83  | 710      | I       |
| 216 | 15.68| g1.5 V | 1.0 | 4.44  | 1.34  | 960      | I       |
| 217 | 14.56| f8 IV  | 0.9 | 2.38  | 1.53  | 1350     | IV      |
| 223 | 15.53| g5 IV  | 0.7 | 3.04  | 1.36  | 1680     | I       |
| 225 | 14.50| g9 IV  | 1.0 | 3.48  | 1.15  | 940      | I       |
| 226 | 16.47| f5 V   | 0.7 | 3.66  | 1.41  | 1900     | IV      |
| 228 | 13.64| g8 IV  | 1.0 | 3.01  | 1.47  | 680      | IV      |
| 231 | 15.02| g2 IV  | 1.0 | 3.02  | 1.63  | 1190     | IV      |
| 233 | 15.41| k2.5 V | 0.8 | 5.92  | 0.49  | 630      | I       |
| 235 | 11.72| k0 III | 1.0 | 0.72  | 1.16  | 930      | IV      |
| 241 | 15.47| g6 III | 0.7 | 1.01  | 2.15  | 2890     | IV      |
| 242 | 13.66| g0 V   | 1.0 | 4.20  | 0.65  | 580      | I       |
| 249 | 14.67| k0.5 III | 0.8 | 0.59  | 1.93  | 2700     | IV      |
| 250 | 14.49| k1.7 III | 0.8 | 0.67  | 1.56  | 2820     | IV      |
| 251 | 13.49| g2.5 V | 1.0 | 4.40  | 1.09  | 400      | I       |
| No. | $V$     | Sp | $p$ | $M_V$ | $A_V$ | $d$ (pc) | Subarea |
|-----|---------|----|-----|-------|-------|----------|---------|
| 252 | 15.45   | g9.5 V | 1.0 | 5.36  | 1.20  | 600      | IV      |
| 254 | 14.00   | k3 V  | 0.8 | 6.63  | 0.71  | 214      | IV      |
| 258 | 14.16   | f7 IV | 0.9 | 2.70  | 1.39  | 1030     | IV      |
| 259 | 13.52   | f7 V  | 0.8 | 3.71  | 0.67  | 670      | I       |
| 266 | 7.70    | k3 III | 1.0 | 0.70  | 0.28  | 221      | IV      |
| 267 | 14.98   | g9 IV | 1.0 | 3.51  | 1.43  | 1020     | IV      |
| 274 | 15.78   | g2 V  | 1.0 | 4.59  | 1.45  | 890      | I       |
| 275 | 12.98   | g5.5 III | 1.0 | 0.71  | 1.54  | 1400     | IV      |
| 277 | 15.06   | g9.5 IV | 0.8 | 2.90  | 1.70  | 1240     | I       |
| 284 | 15.52   | g8 V  | 1.0 | 5.20  | 1.36  | 620      | I       |
| 285 | 12.51   | g8 V  | 1.0 | 5.24  | 0.08  | 274      | I       |
| 286 | 13.56   | k3.5 III | 0.8 | 0.45  | 1.75  | 1880     | I       |
| 290 | 14.45   | k0.7 IV | 1.0 | 2.63  | 1.94  | 950      | IV      |
| 292 | 15.35   | g9 V  | 1.0 | 5.67  | 1.43  | 448      | IV      |
| 293 | 14.97   | f7 IV | 0.9 | 2.37  | 1.21  | 1890     | I       |
| 300 | 11.65   | f6 III | 0.9 | 2.00  | 0.76  | 600      | I       |
| 301 | 14.19   | g9.5 IV | 1.0 | 2.48  | 1.32  | 1200     | IV      |
| 302 | 12.51   | f5 IV | 0.9 | 1.77  | 1.19  | 820      | IV      |
| 304 | 11.37   | g6 V  | 1.0 | 5.14  | 0.13  | 165      | IV      |
| 305 | 14.15   | f6 IV | 0.9 | 2.52  | 1.62  | 1010     | IV      |
| 307 | 16.09   | f8 V  | 0.8 | 4.15  | 1.11  | 1460     | I       |
| 308 | 12.53   | f7 IV | 0.9 | 2.74  | 1.29  | 500      | I       |
| 309 | 13.42   | g5.5 V | 1.0 | 4.83  | 0.74  | 371      | I       |
| 310 | 15.51   | k0.5 V | 1.0 | 5.92  | 1.31  | 453      | IV      |
| 312 | 14.74   | k2 III | 0.8 | 1.16  | 2.15  | 1930     | IV      |
| 314 | 15.68   | g3 V  | 0.8 | 4.71  | 1.46  | 800      | IV      |
| 315 | 15.65   | k0 V  | 0.8 | 5.77  | 1.32  | 520      | IV      |
| 321 | 13.06   | f0 IV | 0.9 | 2.11  | 1.23  | 880      | IV      |
| 323 | 14.12   | f9.5 IV | 0.9 | 2.94  | 1.36  | 920      | IV      |
| 324 | 14.70   | g1.5 IV | 1.0 | 2.51  | 1.10  | 1660     | IV      |
| 325 | 15.94   | f7 V  | 0.7 | 3.94  | 2.09  | 960      | IV      |
| 331 | 14.07   | g9.5 IV | 1.0 | 2.89  | 2.46  | 560      | IV      |
| 333 | 15.26   | f9 IV | 0.9 | 2.36  | 1.44  | 1960     | IV      |
| 335 | 15.81   | f9.5 V | 0.7 | 4.36  | 1.65  | 910      | IV      |
| 337 | 13.35   | f9.5 V | 0.9 | 4.23  | 1.11  | 1000     | I       |
| 339 | 13.78   | k0 III | 1.0 | 0.95  | 1.53  | 1820     | IV      |
| 348 | 13.93   | a8 III | 0.9 | 1.02  | 1.29  | 2110     | IV      |
| 349 | 14.48   | g9.5 III | 1.0 | 1.00  | 1.62  | 2350     | I       |
| 350 | 15.55   | f7 IV | 0.9 | 2.68  | 2.02  | 1480     | IV      |
| 351 | 11.44   | g9 III | 1.0 | 0.27  | 1.61  | 820      | IV      |
| 352 | 15.35   | f9 IV | 0.9 | 2.71  | 1.92  | 1400     | IV      |
| 353 | 15.25   | g2.5 V | 1.0 | 4.60  | 1.63  | 640      | IV      |
| 356 | 12.41   | k0.5 III | 1.0 | 0.73  | 1.55  | 1060     | IV      |
| 360 | 14.05   | b7 V  | 1.0 | -0.11 | 2.20  | 2460     | IV      |
| 362 | 15.77   | g0 V  | 0.8 | 4.45  | 1.57  | 890      | IV      |
| 363 | 14.39   | g9.5 IV | 1.0 | 2.77  | 2.05  | 820      | IV      |
| 369 | 12.68   | f4 IV | 0.9 | 2.38  | 0.97  | 740      | IV      |
| No. | $V$ | Sp | $p$ | $M_V$ | $A_V$ | $d$ (pc) | Subarea |
|-----|-----|-----|-----|-------|-------|----------|---------|
| 373 | 14.02 | g2.5 IV | 1.0 | 3.01 | 1.68 | 740 | IV |
| 377 | 13.10 | a7 IV | 0.9 | 1.34 | 1.82 | 970 | IV |
| 378 | 15.20 | k0.7 III | 0.8 | 0.78 | 1.57 | 3710 | IV |
| 380 | 14.49 | f7 V | 0.9 | 3.95 | 0.85 | 870 | I |
| 383 | 14.87 | k1.2 III | 0.8 | 0.33 | 2.55 | 2500 | IV |
| 384 | 14.94 | g1 V | 0.9 | 4.25 | 1.23 | 780 | IV |
| 386 | 15.57 | g4 V | 1.0 | 4.77 | 1.24 | 820 | |
| 391 | 14.67 | k7 V | 0.8 | 8.15 | 0.00 | 201 | I |
| 394 | 15.21 | g1 IV | 1.0 | 2.81 | 1.51 | 1500 | IV |
| 395 | 12.55 | g6 V | 1.0 | 5.14 | 0.11 | 288 | IV |
| 398 | 15.45 | f9 V | 0.9 | 4.13 | 1.39 | 970 | IV |
| 400 | 13.51 | f8 IV | 0.9 | 2.68 | 1.01 | 920 | IV |
| 403 | 12.80 | f3 III | 0.8 | 1.60 | 1.46 | 890 | IV |
| 409 | 14.75 | k5 V | 1.0 | 7.16 | 0.45 | 268 | IV |
| 411 | 13.37 | f8 IV | 0.9 | 1.88 | 1.18 | 1150 | IV |
| 415 | 15.65 | g1 IV | 0.9 | 2.21 | 1.39 | 2560 | IV |
| 418 | 12.75 | f1 IV | 0.9 | 1.89 | 1.24 | 840 | IV |
| 422 | 15.23 | g3 V | 1.0 | 4.86 | 1.27 | 660 | IV |
| 423 | 15.65 | g1 IV | 0.5 | 3.04 | 1.76 | 1480 | IV |
| 424 | 14.68 | f9 IV | 0.9 | 1.49 | 1.51 | 2170 | IV |
| 426 | 11.18 | f4 III | 0.9 | 1.82 | 1.37 | 395 | V |
| 428 | 12.22 | a5 IV | 0.9 | 0.93 | 1.33 | 990 | IV |
| 431 | 13.33 | k2.2 V | 0.8 | 6.25 | 0.15 | 243 | V |
| 434 | 15.36 | g2.5 IV | 0.9 | 2.53 | 1.56 | 1800 | IV |
| 437 | 16.43 | f7 V | 0.7 | 3.91 | 1.60 | 1520 | IV |
| 439 | 10.70 | f0 IV | 0.9 | 1.84 | 1.04 | 366 | IV |
| 443 | 14.83 | f7 IV | 0.9 | 2.43 | 1.42 | 1570 | IV |
| 446 | 15.57 | g6 IV | 0.8 | 3.17 | 1.45 | 1550 | IV |
| 448 | 11.71 | g9 III | 1.0 | 0.73 | 1.56 | 770 | IV |
| 451 | 14.00 | f7 IV | 0.9 | 2.82 | 1.24 | 970 | IV |
| 456 | 15.60 | k0 III | 0.8 | 0.68 | 1.92 | 3990 | IV |
| 457 | 15.35 | g0 IV | 0.9 | 2.75 | 1.42 | 1720 | IV |
| 460 | 16.35 | g2 V | 0.7 | 4.44 | 1.50 | 1210 | IV |
| 464 | 14.96 | m2.5 V | 0.8 | 10.06 | 0.25 | 85 | IV |
| 466 | 16.55 | g7 V | 0.8 | 5.40 | 1.24 | 960 | IV |
| 469 | 14.49 | k0 IV | 1.0 | 3.56 | 1.27 | 860 | IV |
| 473 | 12.23 | g0 V | 0.9 | 4.33 | 0.18 | 349 | V |
| 476 | 13.74 | g7 V | 1.0 | 5.37 | 0.64 | 352 | IV |
| 477 | 12.57 | f5 V | 0.9 | 2.17 | 1.29 | 660 | IV |
| 480 | 13.74 | k3.5 III | 0.7 | 0.65 | 1.53 | 2060 | |
| 482 | 15.66 | g6 III | 0.8 | 0.85 | 2.10 | 3480 | IV |
| 485 | 13.09 | k0.7 IV | 1.0 | 3.12 | 0.94 | 640 | I |
| 494 | 16.24 | g2.5 V | 0.7 | 4.71 | 1.93 | 830 | IV |
| 495 | 15.22 | g1 V | 0.9 | 4.51 | 0.74 | 990 | I |
| 496 | 13.92 | g1 IV | 1.0 | 2.27 | 1.56 | 1040 | IV |
| 497 | 15.82 | m2 V | 0.8 | 7.37 | 1.83 | 211 | IV |
| 498 | 11.02 | f4 V | 0.9 | 3.45 | 0.14 | 307 | V |
| No. | $V$  | Sp   | $p$  | $M_V$ | $A_V$ | $d$ (pc) | Subarea |
|-----|------|------|------|-------|-------|----------|---------|
| 499 | 12.81| m0 III | 1.0  | -0.68 | 1.63  | 2360     | IV      |
| 500 | 13.65| f9 IV  | 0.9  | 2.71  | 1.08  | 940      | I       |
| 501 | 11.95| f3 IV  | 0.9  | 2.37  | 0.85  | 560      | I       |
| 504 | 15.65| f8 IV  | 0.8  | 2.72  | 1.78  | 1700     | V       |
| 506 | 15.15| k0.5 IV| 0.8  | 3.26  | 1.39  | 1260     | IV      |
| 511 | 16.31| f7 V   | 0.7  | 3.90  | 1.44  | 1560     | I       |
| 513 | 16.00| f9.5 V | 0.7  | 4.37  | 1.66  | 980      | IV      |
| 514 | 15.98| g8 V   | 1.0  | 5.56  | 0.91  | 800      | I       |
| 516 | 15.82| f6 V   | 0.7  | 3.94  | 1.98  | 960      | IV      |
| 519 | 15.33| g5.5 V | 1.0  | 3.05  | 1.42  | 670      | IV      |
| 521 | 14.56| k2.5 V | 0.8  | 6.45  | 0.67  | 309      | I       |
| 523 | 12.54| k1.5 III| 1.0 | 0.90  | 1.34  | 1150     | IV      |
| 527 | 14.30| f6 V   | 0.9  | 3.26  | 1.14  | 950      | I       |
| 531 | 15.71| f8 V   | 0.5  | 4.21  | 1.96  | 810      | V       |
| 533 | 13.61| g0 IV  | 1.0  | 2.38  | 1.44  | 910      | IV      |
| 537 | 16.18| k3 V   | 0.8  | 6.56  | 0.99  | 530      | IV      |
| 538 | 15.91| g3 V   | 0.7  | 4.51  | 2.36  | 640      | V       |
| 540 | 15.16| g9.5 V | 1.0  | 5.55  | 0.86  | 560      | I       |
| 541 | 13.20| k0.7 V | 1.0  | 5.77  | 0.27  | 272      | IV      |
| 544 | 12.27| g2 V   | 0.8  | 4.69  | 0.12  | 311      | IV      |
| 545 | 15.50| f8 V   | 0.7  | 4.11  | 2.11  | 720      | IV      |
| 554 | 12.86| k3 III | 1.0  | 0.67  | 1.22  | 1560     | I       |
| 560 | 14.89| f7 V   | 0.8  | 3.92  | 1.25  | 880      | IV      |
| 562 | 14.30| g2.5 III| 1.0 | 0.84  | 1.95  | 2000     | V       |
| 563 | 14.04| k1 V   | 1.0  | 6.03  | 0.44  | 327      | V       |
| 565 | 14.97| g5 V   | 1.0  | 4.81  | 1.25  | 610      | IV      |
| 567 | 15.73| a9 IV  | 0.8  | 1.97  | 1.86  | 2400     | V       |
| 569 | 13.99| k2.2 III| 0.8 | 0.50  | 2.71  | 1430     | V       |
| 570 | 14.10| k0 IV  | 1.0  | 2.82  | 1.13  | 1070     | I       |
| 572 | 14.56| f6 V   | 0.7  | 3.79  | 1.00  | 900      | I       |
| 574 | 12.44| k2.5 III| 0.7 | 1.41  | 1.11  | 970      | I       |
| 576 | 15.01| g8 III | 0.8  | 0.89  | 3.07  | 1630     | V       |
| 577 | 14.04| k0 V   | 0.8  | 6.02  | 0.50  | 320      | V       |
| 578 | 16.23| g1.5 V | 0.7  | 4.46  | 1.30  | 1240     | I       |
| 581 | 15.48| f8 IV  | 0.9  | 2.37  | 1.49  | 2100     | I       |
| 582 | 15.43| g7 III | 0.8  | 0.71  | 1.57  | 4280     | I       |
| 583 | 14.29| g1.5 V | 0.8  | 4.64  | 0.80  | 590      | I       |
| 595 | 13.18| k2 V   | 1.0  | 6.34  | 1.56  | 114      | V       |
| 597 | 13.31| k0.5 IV| 1.0  | 2.54  | 1.46  | 730      | I       |
| 598 | 15.53| k2 V   | 0.8  | 6.26  | 0.85  | 483      | I       |
| 602 | 16.56| f7 IV  | 0.7  | 2.21  | 1.86  | 3150     | I       |
| 604 | 15.67| f9 IV  | 0.9  | 2.95  | 1.53  | 1730     | IV      |
| 607 | 14.73| f7 IV  | 0.9  | 1.88  | 1.98  | 1490     | IV      |
| 609 | 14.57| k1.2 V | 1.0  | 5.47  | 1.63  | 314      | V       |
| 611 | 9.11 | m0 III | 1.0  | -0.66 | 1.10  | 540      | I       |
| 615 | 14.96| a1 IV  | 1.0  | 0.47  | 1.51  | 3940     | II      |
| 622 | 13.47| k0 III | 0.7  | 0.38  | 2.57  | 1270     | V       |
| No. | V     | Sp | p  | Mv | Av | d (pc) | Subarea |
|-----|-------|----|----|----|----|--------|---------|
| 623 | 14.17 | k1 IV | 0.8 | 2.54 | 1.75 | 950 | II |
| 626 | 12.83 | f5 IV | 0.9 | 2.36 | 1.73 | 560 | V |
| 632 | 11.82 | k0.7 V | 1.0 | 6.00 | 0.20 | 133 | V |
| 633 | 15.36 | g8.5 V | 1.0 | 5.66 | 1.50 | 437 | V |
| 634 | 13.95 | g8.5 IV | 1.0 | 3.16 | 1.44 | 740 | II |
| 636 | 14.57 | k6 V | 0.6 | 7.83 | 0.55 | 173 | V |
| 638 | 13.05 | k1 V | 1.0 | 6.12 | 0.18 | 224 | II |
| 640 | 9.76 | k2.2 III | 0.8 | 0.82 | 0.83 | 420 | II |
| 643 | 12.94 | g4 V | 1.0 | 4.94 | 0.30 | 346 | II |
| 644 | 16.15 | g1 IV | 0.7 | 3.76 | 1.68 | 1390 | IV |
| 649 | 12.10 | k3.7 III | 1.0 | 0.27 | 1.70 | 1070 | II |
| 652 | 13.82 | k3.2 V | 0.8 | 6.69 | 0.18 | 245 | V |
| 656 | 13.67 | g4 V | 1.0 | 4.55 | 0.70 | 485 | II |
| 657 | 12.95 | k0 V | 1.0 | 5.57 | 0.15 | 279 | V |
| 659 | 14.53 | g9.5 III | 0.8 | 1.23 | 1.98 | 1840 | IV |
| 660 | 11.67 | g4 V | 1.0 | 4.95 | 0.19 | 202 | V |
| 662 | 16.55 | f8 V | 0.7 | 3.84 | 1.78 | 1530 | IV |
| 669 | 14.23 | f7 V | 0.9 | 3.74 | 0.95 | 810 | II |
| 671 | 14.24 | k1.2 III | 0.8 | 1.07 | 2.20 | 1560 | IV |
| 674 | 15.54 | g5 IV | 1.0 | 3.48 | 1.22 | 1470 | IV |
| 676 | 16.05 | g8 V | 0.8 | 5.43 | 1.28 | 740 | IV |
| 682 | 14.06 | g8 V | 1.0 | 5.13 | 0.58 | 469 | II |
| 693 | 15.01 | f3 V | 0.6 | 3.14 | 2.53 | 740 | V |
| 694 | 14.28 | f6 III | 0.9 | 1.58 | 1.81 | 1510 | IV |
| 695 | 14.93 | f6 IV | 0.9 | 2.16 | 1.66 | 1660 | IV |
| 696 | 15.34 | g8 V | 1.0 | 5.06 | 0.84 | 770 | IV |
| 698 | 14.34 | g9 III | 1.0 | 0.71 | 1.89 | 2230 | IV |
| 700 | 12.58 | f4 IV | 0.9 | 2.56 | 0.73 | 720 | II |
| 703 | 13.86 | f4 IV | 0.9 | 2.43 | 1.09 | 1160 | II |
| 705 | 15.04 | f7 IV | 0.9 | 2.54 | 1.33 | 1710 | II |
| 706 | 13.75 | f4 V | 0.8 | 3.31 | 1.19 | 1780 | II |
| 708 | 11.81 | f9 V | 0.8 | 4.15 | 0.18 | 312 | V |
| 709 | 15.08 | g6 V | 1.0 | 4.92 | 0.82 | 740 | II |
| 710 | 15.85 | f9.5 V | 0.9 | 4.26 | 1.39 | 1100 | IV |
| 711 | 14.76 | f8 IV | 0.9 | 1.88 | 2.11 | 1420 | IV |
| 712 | 14.60 | f8 IV | 0.9 | 2.86 | 1.15 | 1310 | IV |
| 714 | 12.18 | k2.7 V | 1.0 | 6.47 | 0.29 | 121 | V |
| 719 | 15.21 | f7 IV | 0.9 | 2.00 | 1.29 | 2420 | II |
| 720 | 16.10 | g1 V | 0.7 | 4.45 | 1.76 | 950 | IV |
| 722 | 15.21 | g2 V | 1.0 | 4.67 | 0.44 | 1050 | II |
| 727 | 14.93 | k0.5 V | 1.0 | 5.89 | 0.73 | 460 | II |
| 731 | 12.66 | k2 V | 1.0 | 6.33 | 0.23 | 166 | IV |
| 738 | 15.76 | g8 IV | 0.8 | 2.65 | 1.90 | 1740 | IV |
| 739 | 16.01 | k1.2 V | 0.8 | 6.22 | 0.90 | 600 | IV |
| 742 | 15.61 | g3 V | 0.8 | 4.75 | 1.24 | 840 | IV |
| 750 | 14.49 | f6 IV | 0.9 | 2.69 | 1.54 | 1130 | IV |
| 754 | 11.69 | k4.2 III | 1.0 | 0.21 | 1.16 | 1160 | II |
### Table 1. Continued

| No. | V    | Sp  | p   | $M_V$ | $A_V$ | d (pc) | Subarea |
|-----|------|-----|-----|-------|-------|--------|---------|
| 757 | 12.77| a5  | IV  | 0.9   | 1.32  | 1.42   | 1010    | IV      |
| 760 | 14.01| f6  | IV  | 0.9   | 2.42  | 1.15   | 1220    | IV      |
| 769 | 15.88| g4  V | 1.0 | 5.02  | 1.34  | 800    | IV      |
| 770 | 12.95| f8  IV | 0.9 | 2.75  | 0.88  | 730    | IV      |
| 775 | 16.36| g2  V | 0.7 | 4.80  | 1.39  | 1080   | IV      |
| 776 | 15.88| f6  III | 0.7 | 1.54  | 2.13  | 2770   | IV      |
| 778 | 13.81| f7  IV | 0.9 | 2.73  | 0.95  | 1060   | IV      |
| 780 | 14.27| k0  III | 1.0 | 0.81  | 2.01  | 1940   | IV      |
| 786 | 16.28| g0  IV | 0.7 | 3.10  | 1.74  | 1940   | IV      |
| 789 | 13.86| f7  IV | 0.9 | 2.05  | 1.07  | 1400   | IV      |
| 793 | 15.87| f9  V | 0.8 | 4.04  | 1.39  | 1230   | IV      |
| 797 | 14.05| f6  IV | 0.9 | 2.60  | 1.39  | 1030   | IV      |
| 798 | 14.35| k0.7 V | 1.0 | 5.73  | 0.36  | 447    | II      |
| 799 | 15.09| g5.5  III | 1.0 | 0.80  | 1.58  | 3490   | II      |
| 800 | 15.79| f4  III | 0.7 | 1.92  | 2.02  | 2350   | IV      |
| 803 | 14.71| f0  IV | 0.9 | 2.02  | 1.51  | 1720   | IV      |
| 804 | 14.04| g4  V | 1.0 | 4.15  | 0.17  | 880    | II      |
| 805 | 14.72| g9.5 V | 1.0 | 5.63  | 0.84  | 447    | IV      |
| 810 | 14.57| a8  IV | 0.9 | 1.70  | 2.01  | 1490   | IV      |
| 811 | 12.13| g2.5 IV | 1.0 | 3.35  | 0.51  | 449    | IV      |
| 812 | 15.53| g2.5 V | 1.0 | 4.61  | 1.21  | 870    | IV      |
| 814 | 15.96| f7  IV | 0.7 | 2.48  | 1.93  | 2050   | IV      |
| 815 | 16.01| g2  V | 0.7 | 4.78  | 1.42  | 920    | IV      |
| 820 | 14.63| g1  V | 0.9 | 4.45  | 0.85  | 730    | IV      |
| 821 | 8.99 | f8  V | 0.8 | 4.03  | 0.08  | 95     | IV      |
| 823 | 15.93| k2.5  V | 0.8 | 6.35  | 1.00  | 520    | IV      |
| 825 | 13.74| g1.5  V | 0.9 | 4.56  | 0.66  | 510    | III     |
| 826 | 15.44| k1.2  V | 1.0 | 5.72  | 1.00  | 560    | IV      |
| 828 | 14.09| k0  IV | 1.0 | 2.64  | 1.82  | 840    | IV      |
| 831 | 11.42| f8  V | 0.8 | 4.03  | 0.15  | 281    | IV      |
| 835 | 14.94| f9  IV | 0.9 | 2.10  | 1.42  | 1920   | IV      |
| 839 | 14.33| f8  V | 0.9 | 3.96  | 0.61  | 900    | IV      |
| 844 | 13.03| g8  III | 1.0 | 0.84  | 1.15  | 1610   | II      |
| 846 | 14.70| f9  IV | 0.9 | 2.10  | 1.54  | 1630   | III     |
| 847 | 15.61| g1  V | 1.0 | 4.41  | 0.94  | 1130   | IV      |
| 855 | 15.71| g0  IV | 0.9 | 2.57  | 1.51  | 2120   | IV      |
| 857 | 13.53| f9  V | 0.9 | 4.05  | 0.58  | 600    | III     |
| 861 | 14.91| g0  IV | 1.0 | 2.85  | 1.83  | 1110   | II      |
| 868 | 12.05| g8.5  III | 1.0 | 0.75  | 1.18  | 1060   | IV      |
| 871 | 12.02| f7  IV | 0.9 | 3.00  | 0.79  | 442    | IV      |
| 876 | 15.34| f7  IV | 0.8 | 2.27  | 1.73  | 1860   | IV      |
| 881 | 14.76| f5  IV | 0.9 | 2.63  | 1.37  | 1420   | IV      |
| 887 | 11.51| g1  V | 0.9 | 4.35  | 0.02  | 268    | III     |
| 893 | 15.48| f8  V | 0.8 | 3.91  | 1.09  | 1250   | II      |
| 895 | 14.99| f4  V | 0.9 | 3.49  | 0.96  | 1280   | IV      |
| 896 | 14.10| k0.5  III | 1.0 | 0.78  | 1.63  | 2190   | IV      |
| 903 | 12.54| f8  IV | 0.9 | 2.32  | 1.10  | 670    | IV      |
Table 1. Continued

| No. | $V$  | Sp | $p$ | $M_V$ | $A_V$ | $d$ (pc) | Subarea |
|-----|------|----|-----|-------|-------|----------|---------|
| 905 | 15.24| f9  | 0.9 | 4.08  | 0.67  | 1250     | II      |
| 906 | 14.52| g4  | 1.0 | 5.07  | 0.79  | 540      | II      |
| 910 | 13.79| f3  | 0.8 | 0.90  | 1.60  | 1810     | III     |
| 911 | 13.69| f4  | 0.9 | 2.44  | 1.12  | 1060     | II      |
| 915 | 13.83| g1  | 1.0 | 2.77  | 0.94  | 1060     | II      |
| 917 | 15.52| g6  | 1.0 | 5.14  | 0.55  | 920      | IV      |
| 923 | 14.53| g0  | 1.0 | 4.55  | 0.66  | 730      | II      |
| 924 | 15.36| f7  | 0.9 | 2.61  | 1.19  | 2050     | II      |
| 925 | 14.64| a8  | 1.0 | 1.66  | 1.76  | 1760     | II      |
| 926 | 15.93| f8  | 0.8 | 3.97  | 0.87  | 1660     | II      |
| 928 | 13.04| k1.2| 1.0 | 0.80  | 1.07  | 1710     | II      |
| 932 | 14.03| g6  | 1.0 | 4.78  | 0.46  | 570      | II      |
| 935 | 14.69| g4  | 1.0 | 4.74  | 0.57  | 750      | III     |
| 936 | 14.21| g5.5| 1.0 | 2.41  | 1.38  | 1210     | II      |
| 939 | 14.40| k0.5| 1.0 | 5.84  | 0.59  | 392      | II      |
| 943 | 13.06| g7  | 1.0 | 0.77  | 1.78  | 1260     | III     |
| 946 | 13.48| g2  | 1.0 | 4.42  | 0.37  | 550      | III     |
| 950 | 14.92| g3  | 1.0 | 4.86  | 0.57  | 790      | II      |
| 952 | 11.49| f7  | 0.9 | 2.52  | 0.37  | 530      | III     |
| 953 | 11.40| f5  | 0.9 | 3.56  | 0.28  | 324      | II      |
| 954 | 15.35| k2.7| 1.0 | 6.58  | 0.77  | 398      | III     |
| 956 | 10.90| g0  | 0.8 | 4.18  | 0.15  | 206      | III     |
| 957 | 14.28| g0  | 0.8 | 4.35  | 0.68  | 710      | II      |
| 958 | 15.95| g2.5| 0.8 | 4.69  | 1.31  | 970      | III     |
| 959 | 13.90| g3  | 0.8 | 3.36  | 0.54  | 1000     | II      |
| 962 | 16.10| f8  | 0.7 | 1.85  | 2.11  | 2670     | IV      |
| 963 | 13.38| k2.5| 1.0 | 1.11  | 1.36  | 1520     | IV      |
| 966 | 13.59| a8  | 0.9 | 1.60  | 1.52  | 1240     | II      |
| 971 | 14.78| f5  | 0.9 | 2.57  | 1.23  | 1570     | II      |
| 972 | 12.51| g6  | 1.0 | 5.15  | 0.15  | 276      | II      |
| 973 | 12.63| k0.5| 1.0 | 0.10  | 1.85  | 1370     | III     |
| 977 | 14.66| k1.7| 0.8 | 6.09  | 0.35  | 440      | II      |
| 978 | 15.32| f5  | 0.9 | 2.68  | 1.38  | 1790     | II      |
| 980 | 13.76| g1  | 0.9 | 4.41  | 0.54  | 580      | III     |
| 983 | 14.85| k0.5| 1.0 | 6.00  | 0.47  | 473      | III     |
| 984 | 13.81| f8  | 0.9 | 2.71  | 1.45  | 850      | III     |
| 987 | 15.45| g9.5| 1.0 | 5.54  | 0.89  | 640      | III     |
| 988 | 14.11| f8  | 0.9 | 4.00  | 0.46  | 850      | II      |
| 989 | 10.28| a7  | 0.9 | 2.29  | 0.60  | 300      | II      |
| 991 | 15.13| g1.5| 1.0 | 4.43  | 0.94  | 900      | II      |
| 992 | 15.86| k2  | 0.7 | 6.40  | 0.78  | 550      | IV      |
| 993 | 15.23| g8.5| 1.0 | 3.49  | 1.06  | 1370     | II      |
| 995 | 14.48| g7  | 1.0 | 5.18  | 0.30  | 630      | II      |
| 996 | 16.01| k1.2| 0.8 | 5.51  | 0.35  | 1070     | II      |
| 998 | 14.42| g8.5| 1.0 | 5.56  | 0.53  | 463      | II      |
| 1000| 12.50| f5  | 0.9 | 3.50  | 0.52  | 495      | III     |
| 1001| 12.63| k0.5| 1.0 | 5.74  | 0.09  | 229      | II      |
Table 1. Continued

| No. | $V$   | $Sp$ | $p$  | $M_V$ | $A_V$ | $d$(pc) | Subarea |
|-----|-------|------|------|-------|-------|---------|---------|
| 1007| 15.04 | g1 IV| 0.9  | 3.12  | 0.77  | 1700    | II      |
| 1010| 14.74 | k0 IV| 1.0  | 2.73  | 1.30  | 1390    | II      |
| 1012| 11.77 | g4 V | 1.0  | 4.94  | 0.14  | 218     | II      |
| 1013| 15.41 | g9 III| 0.8  | 1.22  | 1.81  | 2990    | III     |
| 1017| 14.86 | f9 V | 0.8  | 4.47  | 0.74  | 850     | II      |
| 1018| 11.54 | f5 V | 0.9  | 3.43  | 0.38  | 352     | III     |
| 1020| 16.67 | f7 V | 0.7  | 4.09  | 1.23  | 1860    | II      |
| 1021| 14.45 | g8 III| 1.0  | 0.88  | 2.06  | 2000    | III     |
| 1023| 14.21 | g8.5 IV| 1.0  | 3.17  | 1.16  | 950     | II      |
| 1024| 12.38 | k5.5 V| 0.8  | 7.37  | 0.22  | 91      | III     |
| 1026| 14.90 | g8 IV | 1.0  | 3.07  | 1.83  | 1000    | III     |
| 1029| 15.85 | k2.7 V| 0.8  | 6.52  | 0.59  | 560     | II      |
| 1031| 13.31 | f8 IV | 0.9  | 2.57  | 1.03  | 880     | II      |
| 1032| 11.83 | f8 IV | 0.9  | 2.92  | 0.31  | 520     | III     |
| 1033| 13.68 | k0.5 III| 1.0  | 0.82  | 1.60  | 1780    | III     |
| 1040| 16.30 | f9.5 V| 0.8  | 4.40  | 0.98  | 1530    | II      |
| 1041| 15.39 | g7 III| 0.8  | 0.15  | 2.06  | 4320    | III     |
| 1043| 16.50 | g4 V  | 0.7  | 5.20  | 1.14  | 1080    | III     |
| 1044| 15.28 | k0.5 V| 1.0  | 5.89  | 0.50  | 600     | III     |
| 1047| 14.74 | f8 V  | 0.9  | 3.90  | 1.03  | 910     | II      |
| 1054| 14.68 | f9 V  | 0.8  | 4.19  | 0.88  | 840     | III     |
| 1055| 13.96 | g0 V  | 1.0  | 4.48  | 0.32  | 680     | II      |
| 1056| 14.68 | k4.5 V| 1.0  | 7.08  | 0.50  | 264     | III     |
| 1059| 16.12 | g3 V  | 1.0  | 4.84  | 0.86  | 1210    | II      |
| 1061| 12.45 | a8 V  | 0.9  | 2.45  | 0.74  | 710     | III     |
| 1067| 12.63 | f0 III| 0.9  | 1.37  | 1.06  | 1100    | II      |
| 1070| 13.93 | g1.5 V| 1.0  | 4.51  | 0.45  | 620     | III     |
| 1071| 11.32 | k2.2 III| 0.8  | 1.40  | 0.25  | 860     | II      |
| 1074| 14.29 | k2.2 III| 0.8  | 0.96  | 1.47  | 2360    | II      |
| 1076| 10.00 | k0.5 III| 1.0  | 0.52  | 0.42  | 650     | II      |
| 1077| 14.14 | g8 III| 1.0  | 1.10  | 1.44  | 2090    | II      |
| 1078| 15.90 | k2 V  | 0.7  | 6.31  | 0.48  | 660     | II      |
| 1081| 13.57 | g2 V  | 0.8  | 4.55  | 0.39  | 530     | II      |
| 1087| 15.58 | k0 V  | 0.7  | 5.79  | 0.64  | 680     | III     |
| 1089| 15.04 | f5 V  | 0.9  | 3.45  | 1.01  | 1310    | II      |
| 1090| 13.43 | g5 V  | 1.0  | 5.03  | 0.43  | 393     | II      |
| 1093| 14.05 | g5 V  | 1.0  | 4.95  | 0.51  | 520     | III     |
| 1096| 14.54 | k1 III| 0.8  | 1.02  | 1.72  | 2290    | III     |
| 1101| 15.68 | k1.2 V| 0.8  | 6.12  | 0.40  | 680     | II      |
| 1102| 11.35 | g9.5 III| 1.0  | 0.88  | 0.79  | 860     | II      |
| 1105| 15.83 | g8 V  | 1.0  | 5.00  | 0.62  | 1100    | II      |
| 1106| 15.04 | g5 IV | 1.0  | 2.72  | 1.86  | 1240    | III     |
| 1111| 15.29 | g9 V  | 1.0  | 5.79  | 0.44  | 650     | III     |
| 1113| 9.14  | k0 IV | 1.0  | 2.78  | 0.30  | 164     | II      |
| 1114| 13.87 | f9 V  | 0.9  | 4.14  | 0.40  | 730     | III     |
| 1116| 14.54 | g1 V  | 0.9  | 4.37  | 0.98  | 690     | II      |
| 1117| 14.68 | k1.5 V| 1.0  | 6.16  | 0.45  | 412     | III     |
Table 1. Continued

| No.  | $V$   | Sp | $p$ | $M_V$ | $A_V$ | $d$ (pc) | Subarea |
|------|-------|----|-----|-------|-------|---------|---------|
| 1120 | 13.02 | g1 IV | 0.9 | 2.82  | 0.79  | 760    | III     |
| 1122 | 15.74 | g4 V  | 1.0 | 4.74  | 1.03  | 990    | II      |
| 1123 | 15.39 | g9.5 IV | 0.8 | 3.47  | 1.60  | 1160   | II      |
| 1125 | 14.29 | f1 IV | 0.9 | 2.09  | 1.34  | 1490   | II      |
| 1130 | 12.20 | a8 V  | 0.9 | 2.25  | 0.74  | 700    | III     |
| 1131 | 14.56 | k0.5 V | 1.0 | 5.72  | 0.37  | 494    | II      |
| 1134 | 13.54 | f6 V  | 0.8 | 3.97  | 0.39  | 690    | II      |
| 1135 | 13.40 | k1 III | 1.0 | 0.58  | 1.66  | 1700   | II      |
| 1140 | 12.75 | k3 III | 1.0 | 0.27  | 1.91  | 1300   | III     |
| 1141 | 12.86 | g3 V  | 0.8 | 4.80  | 0.25  | 364    | III     |
| 1144 | 14.69 | k1 V  | 1.0 | 5.91  | 0.57  | 437    | III     |
| 1145 | 15.67 | g6 V  | 1.0 | 5.01  | 0.77  | 950    | II      |
| 1148 | 16.01 | k3 V  | 0.7 | 6.69  | 0.43  | 600    | II      |
| 1149 | 11.90 | g3 V  | 1.0 | 4.92  | 0.12  | 236    | III     |
| 1152 | 15.14 | k8 V  | 0.8 | 7.49  | 0.00  | 339    | III     |
| 1153 | 8.09  | f0 V  | 0.9 | 2.63  | 0.09  | 118    | II      |
| 1155 | 14.88 | k3.2 V | 0.8 | 6.72  | 0.41  | 355    | II      |
| 1157 | 11.76 | a9 IV | 0.9 | 2.00  | 0.63  | 670    | II      |
| 1158 | 14.81 | k0 IV | 1.0 | 3.05  | 1.41  | 1170   | II      |
| 1161 | 13.76 | f9 V  | 0.8 | 4.26  | 0.30  | 690    | II      |
| 1162 | 12.28 | g0 V  | 0.8 | 4.20  | 0.31  | 359    | II      |
| 1163 | 14.44 | k0 V  | 1.0 | 5.91  | 0.25  | 453    | III     |
| 1164 | 14.99 | k0.7 V | 1.0 | 5.66  | 0.37  | 620    | II      |
| 1166 | 15.76 | f3 V  | 0.8 | 3.16  | 1.54  | 1630   | II      |
| 1168 | 16.20 | f1 V  | 0.8 | 2.95  | 1.65  | 2090   | II      |
| 1170 | 15.39 | k3 V  | 0.8 | 6.64  | 0.27  | 497    | II      |
| 1173 | 12.62 | f3 V  | 0.9 | 3.16  | 0.44  | 640    | II      |
| 1175 | 13.24 | g8.5 IV | 1.0 | 3.66  | 0.43  | 670    | II      |
| 1177 | 15.09 | g2 V  | 0.8 | 4.67  | 1.15  | 710    | III     |
| 1178 | 14.79 | f6 V  | 0.8 | 3.92  | 0.86  | 1000   | II      |
| 1180 | 14.45 | f9.5 IV | 0.9 | 2.18  | 1.08  | 1730   | II      |
| 1183 | 15.91 | g1 V  | 0.8 | 4.58  | 0.84  | 1250   | II      |
| 1186 | 14.58 | g5 V  | 1.0 | 4.84  | 0.60  | 670    | II      |
| 1187 | 14.55 | g2 V  | 0.9 | 4.71  | 0.41  | 770    | III     |
| 1188 | 14.58 | g1.5 V | 1.0 | 4.51  | 0.31  | 900    | II      |
| 1190 | 14.93 | f6 IV | 0.9 | 2.43  | 1.56  | 1540   | III     |
| 1194 | 15.76 | k2.5 V | 0.8 | 6.49  | 0.32  | 610    | II      |
| 1202 | 13.91 | g0 V  | 1.0 | 4.30  | 0.79  | 580    | II      |
| 1203 | 13.74 | g0 V  | 0.9 | 4.28  | 0.38  | 650    | II      |
| 1205 | 15.02 | f8 V  | 0.8 | 4.15  | 1.38  | 790    | II      |
| 1209 | 15.43 | k0 V  | 1.0 | 5.90  | 0.68  | 590    | III     |
| 1214 | 12.51 | k0.5 III | 1.0 | 1.06  | 1.34  | 1050   | II      |
| 1215 | 13.29 | g9.5 III | 1.0 | 0.75  | 1.46  | 1650   | II      |
| 1217 | 14.63 | g9.5 V | 1.0 | 5.49  | 0.29  | 590    | II      |
| 1218 | 15.95 | f9 V  | 0.9 | 4.07  | 1.28  | 1320   | II      |
| 1219 | 16.01 | k3 V  | 0.8 | 6.53  | 0.40  | 660    | II      |
| 1221 | 10.54 | f0 IV | 0.9 | 2.14  | 0.28  | 421    | II      |
Table 1. Continued

| No. | $V$  | Sp | $p$ | $M_V$ | $A_V$ | $d$(pc) | Subarea |
|-----|------|----|-----|-------|-------|---------|---------|
| 1222| 14.49| g0 V | 0.9 | 4.21  | 0.39  | 950     | II      |
| 1224| 15.94| k3 V | 0.8 | 6.50  | 0.47  | 620     | II      |
| 1225| 15.32| g2 V | 0.8 | 4.67  | 0.62  | 1010    | II      |
| 1226| 12.63| g1 V | 0.9 | 4.31  | 0.23  | 414     | II      |
| 1227| 13.32| g5.5 V | 1.0 | 5.10  | 0.37  | 372     | II      |
| 1228| 14.31| g7 V | 1.0 | 5.23  | 0.65  | 486     | II      |
| 1233| 14.78| f9.5 V | 0.8 | 4.39  | 0.29  | 1050    | II      |
| 1236| 12.95| g1.5 V | 1.0 | 4.42  | 0.37  | 427     | II      |
| 1238| 15.84| k3.5 V | 0.7 | 6.89  | 0.51  | 488     | II      |
| 1239| 12.99| f8 V | 0.9 | 3.95  | 0.29  | 560     | II      |
| 1240| 13.63| g1 V | 0.8 | 4.56  | 0.22  | 590     | II      |
| 1243| 13.67| g3 V | 1.0 | 4.70  | 0.31  | 540     | II      |

Fig. 1. Dependence of the $A_V$ extinction on distance in the whole area. The three dotted curves show the limiting magnitude effect for A0 V, F0 V and G0 V stars. The curve at the right-hand upper corner is also valid for K0 III stars since their absolute magnitudes are close to those of A0 V stars. The lower segmented curve is the dependence of the extinction on distance for the Galactic latitude $+14.2^\circ$ calculated by the Parenago formula (see the text). The error bars correspond to standard deviations of the distance and the extinction at 0.5 kpc and 2 kpc distances. The two vertical lines mark the mean distances of the clouds.
Figure 1 shows the plot $A_V$ vs. $d$ for stars in the whole area. The three dotted curves correspond to A0 V (or K0 III), F0 V and G0 V stars at the limiting magnitude $V_{\text{lim}} = 16.0$. The stars of these spectral types (and absolutely fainter) above the corresponding curves are affected by the limiting magnitude, i.e., stars with high extinctions are missing at these distances. Consequently, the plot cannot be used for estimating both the mean and the maximum extinctions. However, up to a distance of 1 kpc all the stars absolutely brighter than G0 V are well represented in the areas where $A_V$ is smaller than $\sim 2$ mag. At $d = 1$ kpc and $A_V = 2$ mag, only G, K and M dwarfs near the limiting magnitude are missing. In the upper part of Figure 1 the error bars of the distance and $A_V$ are shown for the two distance values. They correspond to an error of $\pm 0.1$ mag in $A_V$, $\pm 0.5$ mag in $M_V$ and $(-20, +26)\%$ in the distance.

Fig. 2. The division of the investigated area into five subareas exhibiting slightly different dependencies of $A_V$ on distance. The extinction map from Dobashi et al. (2005) atlas and the stars down to $V = 14$ from GSC are shown in the background.
The segmented curve in Figure 1, which starts from the origin of the coordinates, corresponds to the exponential extinction law for the Galactic latitude $b = +14.2^\circ$, calculated by the Parenago formula with the extinction coefficient $A_V = 1.5 \text{ mag/kpc}$ and the half-thickness of the dust layer $\beta = 0.11 \text{ kpc}$ (Parenago 1945; Sharov 1963; Straižys 1992, p. 146). It is evident that the Parenago curve is in agreement with the positions of low-extinction stars located closer to us than 500–700 pc.

For determining the distance to a dark cloud we usually use stars situated at a steep rise (or jump) of the extinction at the front edge of the cloud. However, some of these stars can have negative distance errors which originate mainly from the errors in their absolute magnitudes. Consequently, the true distance to the cloud can be larger than the distance corresponding to the jump defined by the stars apparently closest to the Sun. The true distance can be found as $d = d(\text{front}) + 0.2d$, or $d = d(\text{front}) / 0.8$, where $0.2d$ is the negative distance error when the error of the absolute magnitude $\Delta M_V = +0.5$.

However, the described situation takes place only in the case when a statistically significant number of stars at the extinction jump is available. In our case, at the expected cloud distance we have only a few stars with large extinctions. It is quite possible that some of them really have a negative error of the distance but it is also possible that their distance error happens to be zero or even positive, and we have no reason to apply the above described correction to their apparent distances. A more realistic value of the cloud distance can be obtained by averaging distances of the reddened stars in the interval between $d - 0.20d$ and $d + 0.26d$ where $d$ is the true cloud distance.

In Figure 1 we can see that at $\sim 250$ pc a steep rise in the extinction takes place. However, two of the stars, Nos. 595 and 636 in the catalog of Paper I, exhibit too large extinction values, $A_V = 1.56$ and $0.55$ mag, at small distances, 114 pc and 173 pc, respectively. The first of these two stars will be discussed below in this section. Both stars are excluded from determining the cloud distance. The remaining 10 stars with distances between 210 and 330 pc and $A_V \geq 0.5$ mag have the mean distance $282 \pm 42$ pc (standard deviation) which may be considered as the distance of the nearest cloud. This result should be considered as more accurate than the value of distance found by Straïžys et al. (1992) applying a similar method for only four stars of magnitudes 11–12. Two of them in our Paper I were suspected as binaries.

At distances larger than 250 pc the extinction continues to rise almost up to 1 kpc. However, the presence of another jump (or jumps) of the extinction can be suspected. The most probable jump is observed between 560 and 875 pc, where 560 pc is the distance to the front edge, and the distance range is defined by $d - 0.20d$ and $d + 0.26d$. Within this distance range we have 10 stars with $A_V \geq 1.8$ mag. Their mean distance is $715 \pm 110$ pc (standard deviation).

Trying to better understand the extinction vs. distance relation, we have split the investigated field into five subareas with the boundaries shown in Figure 2 and with the extinction map from the Dobashi et al. (2005) atlas and the stars down $V = 14$ mag from the GSC catalog plotted in the background. Each of these subareas exhibits a somewhat different form of the $A_V$ vs. distance dependence. In the following, the results of the extinction dependence on distance in these subareas will be described.
Fig. 3. The same as in Figure 1 but for Subarea I.

Fig. 4. The same as in Figure 1 but for Subarea II.
Fig. 5. The same as in Figure 1 but for Subarea III.

Fig. 6. The same as in Figure 1 but for Subarea IV.
Figure 3 shows the $A_V$ vs. $d$ plot for Subarea I located along the right edge of the field. The first two reddened stars with $A_V$ between 0.6–0.8 mag are seen at an apparent distance of $\sim 290$ pc, i.e., quite close to the mean distance of the first cloud estimated from Figure 1. A few more jumps between 500 pc and 750 pc are also possible. The mean extinction value at distances $> 1.0$ kpc is about 1.3 mag, and the maximum value is close to 1.75 mag.

Figure 4 shows the $A_V$ vs. $d$ plot for Subarea II located at the left upper corner of the area. Here, the nearest considerably reddened star is found at the apparent distance 300 pc, and the second jump is seen at $\sim 700$ pc. At $d > 1$ kpc the extinction remains more or less constant with a mean value of 1.3 mag. In this subarea a group of about 12 stars at a distance of 800–1100 pc exhibits quite low extinction, with the values between 0.2 and 0.6 mag. Probably, these stars are seen in the directions of relatively transparent windows. They are scattered over the whole subarea.

Figure 5 shows the $A_V$ vs. $d$ plot for Subarea III located at the lower left corner of the field. The positions of the two extinction jumps here cannot be estimated reliably but the height of the second jump is almost 1 mag, giving a mean extinction of 1.8 mag at $d > 1$ kpc.

Figure 6 shows the $A_V$ vs. $d$ plot for Subarea IV which surrounds the central dark cloud on three sides. The extinction jumps are close to the distances observed in other subareas. The extinction values show a considerable scatter (between 1.0 and 2.2 mag), with the mean value being about 1.6 mag. Two stars in the subarea exhibit the extinction values around 2.5 mag.

**Fig. 7.** The same as in Figure 1 but for Subarea V.
In Figure 7 we show the $A_V$ vs. $d$ plot for Subarea V which includes the darkest segment of the dust cloud with the reflection nebula NGC 7023. Only 14 classified stars with $A_V > 1.0$ have been found in this direction. Among these the most interesting is the above-mentioned star No. 595. Its photometric spectral type is K2 V, $V = 13.18$, $A_V = 1.56$ and $d = 114$ pc. It is strange to find this large extinction at such a small distance. The classification of the star by all of the methods applied is of good accuracy and coinciding. The small apparent distance of the star can be explained by its possible duplicity. If it is a binary with two identical components, the combined absolute magnitude should be more negative by 0.75 mag and the distance larger by a factor of 1.41, i.e., $114 \times 1.41 = 161$ pc, which is more realistic than the value for a single star, but still too small compared to the cloud distances in other subareas.

Other stars in Subarea V classified in Paper I are too scanty to estimate cloud distances. However, their distribution in the plot (Figure 7) is not in contradiction to the apparent distances of the two clouds at 282 pc and 715 pc. The largest extinction found in Subarea V is close to 3 mag, but this is not the real maximum value since the stars with larger extinctions are absent in our sample due to the limiting magnitude effect. With the help of 2MASS photometry we have found in this area a few red giants having $A_V \approx 15$ mag.

4. DISCUSSION AND CONCLUSIONS

The dust cloud TGU 629, surrounding the reflection nebula NGC 7023, belongs to a giant dust and molecular cloud system known as the Cepheus Flare. In the summaries of distance determinations of different objects in this system, Kun (1998) and Kun et al. (2008) came to the conclusion that the system either has a considerable depth or consists of several layers with distances ranging from 200 to 500 pc. Two layers of interstellar gas were found by radio observations by Heiles (1967) in the neutral hydrogen 21 cm line and by Grenier et al. (1989) in the CO molecular lines. Applying the kinematical method to velocity profiles of the lines, Grenier et al. find the approximate distances to the layers: 300 and 800–900 pc.

Our results described in Section 3 also give evidence that dust clouds in the vicinity of NGC 7023 concentrate at least in two layers at 282 pc and 715 pc. There is a possibility that the true distances of these cloud layers are not the same throughout the area. However, the number of stars at the extinction jumps in different subareas is too small to be sure that these distance differences are real. The extinction vs. distance plots also allow to suspect that more clouds are present along the line of sight. This is in agreement with the map of the CO intensity distribution (Dame et al. 2001) which evidences that the molecular cloud structure in the Cepheus Flare is quite clumpy and fragmented.

Our estimates of cloud distances are in satisfactory agreement with those found by Grenier et al. (1989) from kinematics of the CO clouds. The CO radial velocities show that at the Galactic longitude $\ell = 104^\circ$ both clouds are connected by a bridge. The distant CO layer should be more prominent at larger Galactic longitudes, i.e., on the left side of our area (Subareas II, III and, partly, IV). This is in agreement with our results.

If we accept that dust clouds in this direction reach a distance of 700 pc, the depth of the cloud layer should be about 400 pc. The length of the whole Cepheus Flare cloud system ($\sim 18^\circ$) corresponds to $\sim 95$ pc at a distance of 300 pc and to $\sim 220$ pc at a distance of 700 pc. It seems possible that the Cepheus Flare has its
extension known as the Polaris Flare (Heithausen et al. 1993; Dame et al. 2001). In this case the whole complex of molecular clouds from $\ell, b = (100^\circ, +14^\circ)$ to $(126^\circ, +30^\circ)$ has a length of $\sim 30^\circ$ and the projected complex length is from $\sim 160$ pc at a distance of 300 pc to $\sim 375$ pc at a distance of 700 pc. The apparent width of the Cepheus and Polaris Flares is only $\sim 8^\circ$, which corresponds to 42 pc at a distance of 300 pc and 100 pc at 700 pc.

The projected length of the cloud system at 700 pc (375 pc) is comparable to the observed depth of the complex (400 pc), i.e., the complex looks like a pancake, and our line of sight runs along its plane. The heights of the two cloud layers above the Galactic plane in the direction of NGC 7023 are 75 pc and 170 pc.

To have the estimates of cloud distances more accurate, one must minimize the errors of absolute magnitudes of the stars which define the jumps in the extinction vs. distance dependence. This can be done either by spectral observations of these stars to verify their spectral and luminosity classes or by determining trigonometric parallaxes. Within a few years, in the case of the success of the Gaia mission, the distance problem of these reddened stars will be solved.

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