Dust Ring at the Camelopardalis and Perseus Border

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Dust Ring

In the Camelopardalis segment of the Milky Way, optical, infrared and radio observations reveal the presence of a dust ring with a diameter of about 8 deg, centered at Galactic longitude 152 deg, and Galactic latitude +0.5 deg, at the open cluster NGC 1528 (Straižys & Laugalys, 2007, 2008). Fig. 1 presents the image of the dust distribution, from Dobashi et al. (2005) obtained by star counts in the DSS database. The ring includes the following TGU clouds: 942 (P7, P8), 994, 1003, 1036, 1041, 1027, 1014, 1006, 989.
We have started the investigation of the dust clouds in different segments of the ring with the aim to determine their distances, applying the Vilnius seven-color photometric system.

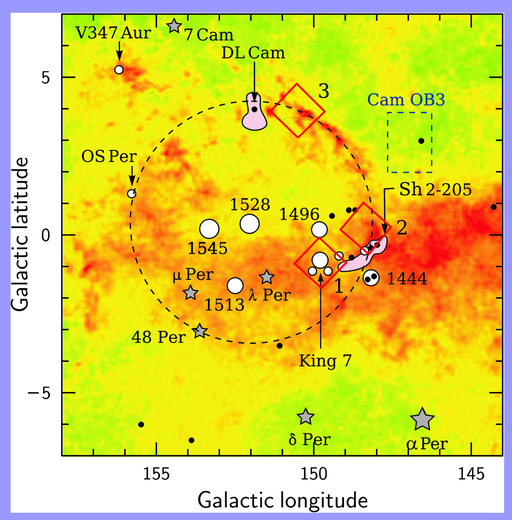

Figure 1. Dust clouds in Camelopardalis from Dobashi et al. (2005)

Observations and Data Processing

Seven-color CCD photometry in the Vilnius system UPXYZVS (see Table 1) in the three ring areas (Area 1, Area 2, Area 3) was obtained in 2009-2010 with the Maksutov-type 35/51 cm telescope of the Moletai Observatory in Lithuania, equipped with a VersArray 1300B liquid nitrogen cooled camera. This camera has a backside-illuminated 1340x1300 pixel chip, the image scale is 3.38″ per pixel, which results in a field size of 1.26°x 1.22°. In total 198 frames of the three areas with different exposure lengths were obtained. The Vilnius photometric system and its possibilities are described in detail in the Straižys (1992) monograph. For the processing of images the IRAF package was used. To extract the instrumental magnitudes, we applied both the aperture and point spread function (PSF) photometry modes. A detailed description of flatfielding and photometry can be found in Zdanavičius et. al (2008b). The transformation of instrumental magnitudes and color indices to the standard Vilnius system was based on stars, that were observed in the field photoelectrically by Zdanavičius et al. (2001) and Zdanavičius & Zdanavičius (2002). The spectral classification was based on the methods, described in Zdanavičius et al. (2010), Straižys et al. (2013) and Milašius et al. (2013).

In addition to the observations with the Maksutov telescope, one field, centered on the open cluster King 7 (resides in Area 1) was observed in 2012-2013 with the 1.8 m Vatican Observatory Advanced Technology Telescope (VATT) on Mt. Graham International Observatory (Arizona) equipped with a 4K backside illuminated CCD camera and liquid nitrogen cooling. The camera contains a 62×62 mm chip which gives a 13′×13′ field-of-view, with a scale of 0.38/pixel (binned 2×2). The transformation equations to the standard system and the classification methods are the same as it was mentioned above.

Table 1. Wavelengths and widths of the Vilnius system

Vilnius Filters	U	P	X	Y	Z	V	S
Mean wavelength (nm)	345	374	405	466	516	544	656
Half-width (nm)	40	26	22	26	21	26	20

Results and Discussion

Interstellar extinction in Area 1

The Area 1 is about 1.5 square degrees, centered at α (J2000) = $3^h59^m00^s$, δ (J2000) = +51°50′00″ (l = 149.7°, b = -1.0°) and is around the open cluster King 7. The results of photometry of 1549 stars down to V~16 mag in the area are presented in Zdanavičius et al. (2010b), which gives the folowing information: star number, equatorial coordinates J2000.0, magnitude V, color indices U-V, P-V, X-V, Y-V, Z-V and V-S, photometric spectral type in the MK system, interstellar extinction A_V and distance d in pc. Figure 2 shows A_V versus distance plot for 1231 stars with the most reliable spectral clasification observed with Maksutov (908) and VATT (323) telescopes. As it is seen the extinction start rise from about 200 pc reaching A_V = 2 mag at a distance of about 1 kpc. The second and the third jump could also be identified from about 1.5 kpc and 4.5 – 5 kpc .

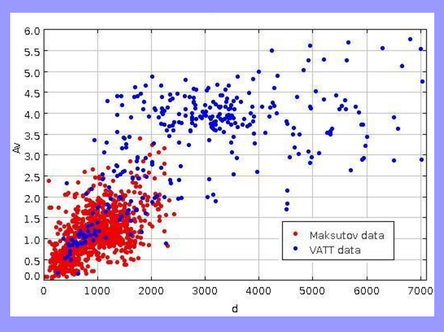

Figure 2. A_V vs d plot for 1231 stars in Area 1

Interstellar extinction in Area 2

The Area 2 is about 1.5 square degrees, centered at α (J2000) = $3^h57^m00^s$, δ (J2000) = +53°40′00″ (l = 148.3°, b = +0.2°) and is located at the northern edge of the emission nebula Sh2-205. The results of photometry of 922 stars down to V~17 mag in this area are presented in Čepas et al. (2013), which gives the folowing information: star number, equatorial coordinates J2000.0 from PPMXL (Roeser et al. 2010), magnitude V, color indices U-V, P-V, X-V, Y-V, Z-V and V-S, photometric spectral type in the MK system. Figure 3 shows A_V versus distance plot for the stars of Area 2 with reliable spectral classification. A steep rise of Av between about 200 pc to 400 pc is seen. Then for most of the stars extinction remains almost constant, except of a group of stars with about two times lager extinction, that seems has no dependence on the distance.

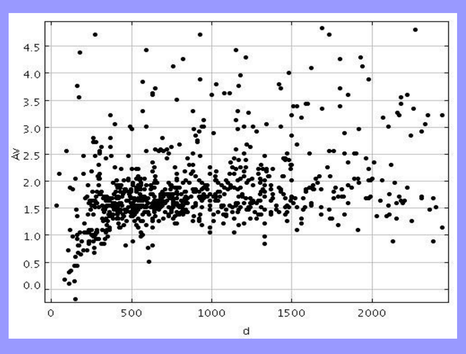

Figure 3. A_V vs d plot for 802 stars in Area 2

Interstellar extinction in Area 3

The Area 3 is about 1.5 square degrees, centered at α (J2000) = $4^h25^m30^s$, δ (J2000) = +54°55′00″ (l = 150.5°, b = +4.0°) and is located in the region of dark cloud TGU H994 P1 (or LDN 1399, LDN 1400 and LDN 1402). The results of photometry of 727 stars down to V~17 mag in this area are presented in Čepas et al. (2013b), which gives the following information: star number, equatorial coordinates J2000.0 from PPMXL (Roeser et al. 2010), magnitude V, color indices U-V, P-V, X-V, Y-V, Z-V and V-S, photometric spectral type in the MK system. Figure 4 shows A_V versus distance plot for Area 3 that have reliable spectral classification. As in previous extinction figures, a steep rise of extinction is clearly visible starting from from about 200 pc.

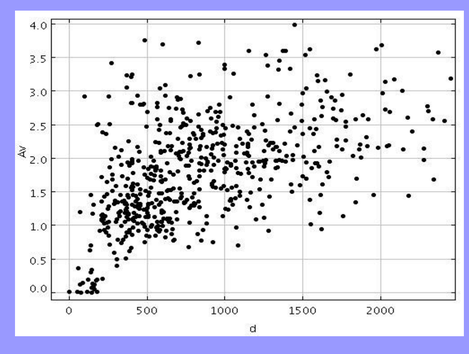

Figure 4. A_V vs d plot for 602 stars in Area 3

Conclusions

From the plots of interstellar extinction vs. distance in Areas 1, 2 and 3 we conclude, that in the investigated areas the interstellar extinction could be caused by dust clouds that could be physically linked to the investigated ring, placing its distance to about 200-300 pc.

Acknowledgements

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References

Čepas V., Zdanavičius J., Zdanavičius K., Straižys V., Laugalys V. 2013, Baltic Astronomy, 22, 223 (Paper II)
Čepas V., Zdanavičius J., Zdanavičius K., Straižys V., Laugalys V. 2013b, Baltic Astronomy, 22, 243 (Paper II)
Dobashi K., Uehara H., Kandori R. et al. 2005, PASJ, 57, S1
Milašius K., Boyle R. P., Vrba F. J. et al. 2013, Baltic Astronomy, 22, 213
Roeser S., Demleitner M., Schilbach E. 2010, AJ, 139, 2440
Straižys V. 1992, *Multicolor Stellar Photometry*, Pachart Publishing House, Tucson, Arizona; available in pdf format from http://www.itpa.lt/MulticolorStellarPhotometry/
Straižys V., Laugalys V. 2007, Baltic Astronomy, 16, 167
Straižys V., Laugalys V. 2008, in *Handbook of Star Forming Regions*, vol. 1, ed. B. Reipurth, ASP, p. 294
Straižys V., Boyle R. P., Janusz R. et al. 2013, A&A, 554, A3
Zdanavičius J., Černis K. Zdanavičius K., Straižys V. 2001, Baltic Astronomy, 10, 349
Zdanavičius J., Zdanavičius K. 2002, Baltic Astronomy, 11, 75
Zdanavičius K., Zdanavičius J., Straižys V., Kotovas A. 2008b, Baltic Astronomy,17, 161
Zdanavičius J., Bartašiūtė S., Boyle R.P., Vrba F.J., Zdanavičius K. 2010, Baltic Astronomy, 19, 63
Zdanavičius J., Čepas V., Zdanavičius K., Straižys V. 2010b, Baltic Astronomy, 19, 197 (Paper I)