Interstellar polarisation towards a region around B5

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Abstract

Interstellar polarization was known to give information on the direction of galactic magnetic fields. Nowadays, the Gaia parallaxes and various photometric surveys allow the wavelength dependence of this polarization to provide even more information about the magnetic fields and dust grains.

We consider the region of the interstellar medium towards the Bok globule Bernard 5 (B5, l 161 , b 17). We performed a spectroscopic study of stars in this region at 0.7-m telescope of the Abastumani observatory. We carried out $UBVRI$ polarimetric observations of some of our stars at 1.25 and 2.6-m CrAO telescopes and determined the parameters of the dependence of polarization on wavelength. Using stellar photometry and parallaxes available from recent sky surveys, we have estimated the visual extinction towards the observed stars. By analyzing the relationship between the parameters of the interstellar polarization and extinction for stars located at dierent distances and at dierent angular distances from the B5 globule, the structure and properties of the interstellar medium in the region under consideration are discussed.

Introduction

Interstellar polarization is a phenomenon associated with two components of the interstellar medium (ISM)—cosmic dust and galactic magnetic fields—that are widely studied today. Although the phenomenon was discovered independently about 75 years ago by Hall, Hiltner, and Dombrovsky, observational data about it is still quite scarce, especially about its wavelength dependence. Of particular interest today are polarization changes revealed near star-forming regions. Such data becomes more informative due to stellar photometry and parallaxes now available.

Observations

We spectroscopically observed the stars surrounding the B5 globule at Abastumani Astrophysical Observatory in 1990. Based on these data, we carried out a MK spectral classification of almost 50 bright stars.

Figure 1 presents a comparison between our results and other data. We find general agreement in the data, but some details should be noted. The standard work of Cannon and Pickering for HD/HDE stars agrees well with our results, with the exception of the A–F stars. More recent studies, collected in the well-known Ski catalog, better correspond to our data. Note that our classes of A stars are on average 2 subclasses earlier than in other works. which is shown by the dashed line in Fig. 1.

We also carried out the multi-wavelength polarimetric observations of about 20 of our stars at the Crimean Observatory (at the ZTS in the $UBVR$ bands and at the AZT-11 in the $UBVRI$ ones) in the 1990s.

Our data on the wavelength dependence of the polarization degree $P(\ )$ were approximated by the Serkowski curve. Our fitting was performed using the Levenberg-Marquardt method. For most stars we did not have good enough data to estimate all three parameters of the curve (P_{max}; $_{max}$; K) and used the mean relation $K = 1.7\ _{max}$ to rule out the curve width parameter K.

Photometric spectral classification

Today, one can derive the visual extinction A_V to the stars in dierent ways. For some reasons, we have selected our own way. We did not fix the parallax and resulting spectral type of our stars, but consider both as free parameters.

To determine the spectral type Sp, distance d and visual extinction A_V, we vary them to find a minimum of the residual between calculated X_n^{calc} and observed X_n^{obs} (with uncertainty $_{X_n}$) stellar magnitudes for N^{obs} bands:

$$^2 = \frac{1}{N^{obs} - 3} \sum_{n=1}^{N^{obs}} \left[\frac{X_n^{calc}(Sp; A_V; d) - X_n^{obs}}{_{X_n}} \right]^2. \quad (1)$$

To calculate the stellar magnitude in an X band, we use the absolute visual magnitudes of the stars, the mean intrinsic colours, and the mean galactic extinction curve as follows: $X^{calc}(Sp; A_V; d) = M_V(Sp) - (V - X)_0(Sp) + A_X(A_V) + 5\log_{10}(d/10)$.

We applied this classification procedure to the photometric and astrometric data available for our stars. The results of our approach were compared with the data of StarHorse2 (Anders et al. 2022). We find that the results are generally consistent, and hence our approach applied to original photometric data (more accurate than in the surveys) can be useful.

We have also compared the values of T_e obtained from spectral and photometric classifications and noticed a larger scatter in the regions of A5–G0 stars and earlier than B9 (see Fig. 1).

Discussion

We used our results to consider the relations between the extinction (A_V) and polarisation parameters (P_{max}; $_{max}$;) and the distance d to the stars (mostly located at d = 70 700 pc).

We deduced that there is no significant contribution of the Perseus molecular cloud complex (d 300 pc) assumed in some works. So, we deal mostly with the only dust layer related to the Taurus molecular cloud complex (TMC, d 150 pc). We find that in this layer A_V = 0.6 1.4 mag, P_{max} = 0.9 0.4 % changes randomly, while the position angle = 55 15 deg almost remains the same with an increase of d. Wavelength of the maximum polarization is also nearly constant $_{max}$ = 0.53 0.04 m. We have compared these results with the estimates of these parameters made in other works that considered close parts of the TMC and found a reasonable agreement.

We have also compared the obtained relation of the polarizing eciency P_{max}/A_V on $_{max}$ with theoretical analysis of Voshchinnikov et al. (2016). We find that in the considered part of the TMC the dust is typical of the diuse interstellar medium, but the magnetic field is tilted more than 45 degrees to the plane of the sky. The low polarization eciency we achieved cannot be explained by an overestimating of A_V, since this eect can increase P_{max}/A_V less than by 1.3 times.

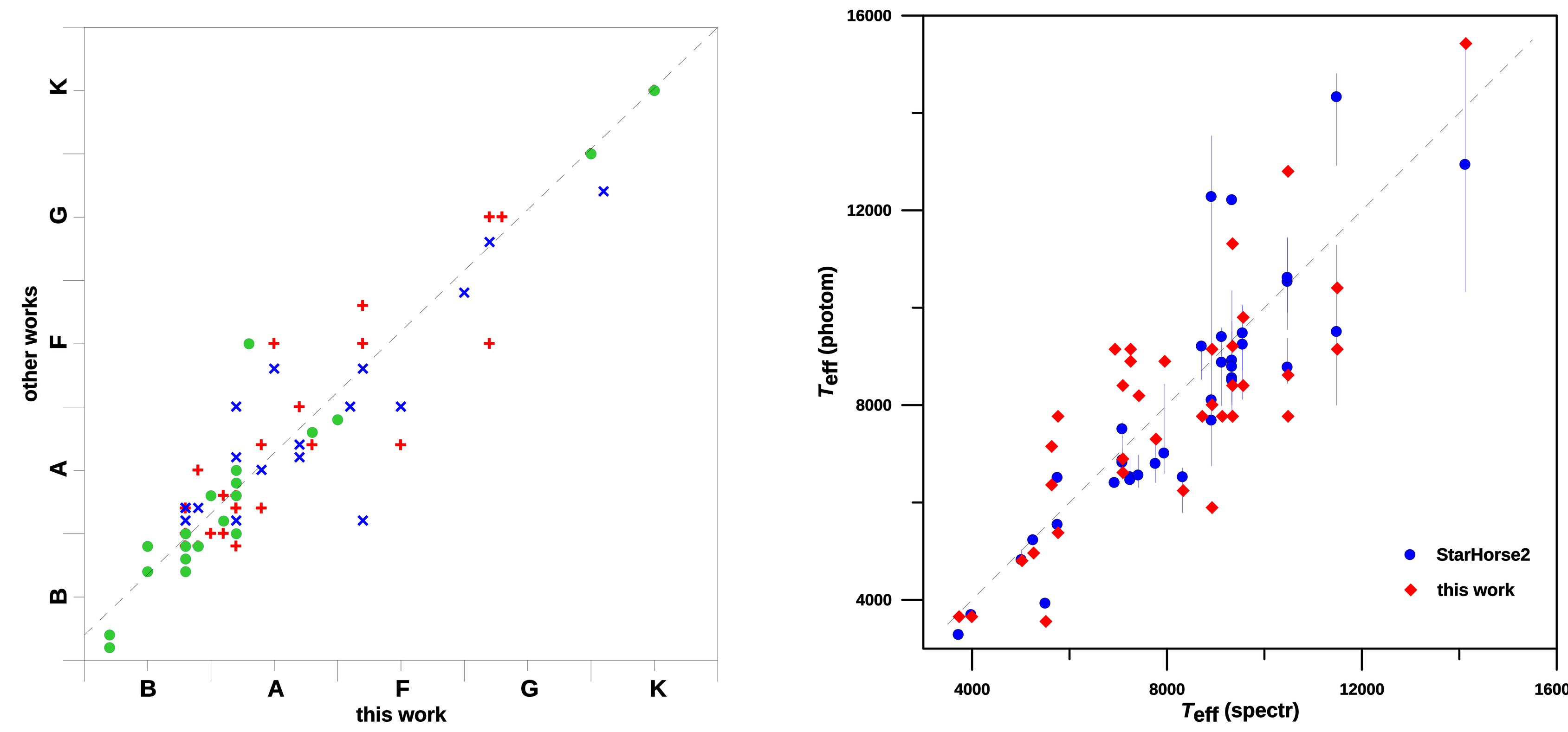

Fig. 1. Left panel: A comparison of the spectral classification made in this and other works: (red) pluses – HD/HDE, (blue) crosses – LAMOST DR7, and (green) circles – some mean classes from Ski catalog. Right panel: A comparison of T_e derived from StarHorse2 (blue circles) and our (red rhombus) photometric classifications and from spectral studies.

Summary

We present the results of our spectroscopic and $UBVRI$ polarimetric observations of about 40 stars in a vicinity of the B5 globule. We have also performed photometric spectral classification of the stars to estimate A_V and compared its results with the data of the spectral study and other photometric classifications like StarHorse2.

We find that for the majority of our stars interstellar extinction and polarization are formed in a dust layer related to the Taurus molecular cloud complex at d 150 pc. Our results allow us to evaluate the parameters of this layer: A_V = 1.0 0.4 mag, P_{max} = 0.9 0.4 %, $_{max}$ = 0.53 0.04 m, = 55 15 deg. They are in a reasonable agreement with the estimates made by other authors for close fields.

We have compared the derived correlation of the polarizing eciency P_{max}/A_V and the maximum polarization wavelength $_{max}$ with theoretical dependencies and suggested that the magnetic field in the layer makes an angle less than 45 with l.o.s.

In more detail the results will be described by Krayani, Il'in (2024).

References

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