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Polarimetric study of the interstellar medium in the region surrounding the dark cloud [DB2002B] G273.29+2.47

Maria E. S. Galvao[1], W.J.B. Corradi[2,1], W. Reis[3,1], D. Brissi[4], & N. Sasaki[5]

[1] UFMG e-mail: mariagalvao@ufmg.br
[2] LNA e-mail: wbcorradi@lna.br
[3] IBMEC e-mail: wilsonr@fisica.ufmg.br
[4] IFSP Birigui e-mail: deidimar@ifsp.edu.br
[5] UEA e-mail: nsasaki@uea.edu.br

Abstract. This study is part of a wider investigation that aims to map the local interstellar medium. The present work seeks to examine the number of components, the intensity, and the orientation of the magnetic field through polarization (P), the polarization angle (θ), and the color excess $E(b-y)$, evaluated using Polarization-Distance Diagrams, Color Excess-Distance Diagrams, and Alignment Efficiency Diagrams $P/E(b-y)$ diagrams as a function of distance. These aspects were analyzed in the direction of the Vela constellation, near the dark cloud [DB2002b] G273.29+2.47. For this purpose, polarimetric data collected at the Pico dos Dias Observatory (OPD/LNA) were used, obtained with the 1.60 m P&E telescope in 2023, using the IAGPOL in the V filter. In accordance with the results obtained by Galvão et al. (2024), based on the Color-Distance Excess Diagrams $E(b-y)$, the Polarization-Distance Diagrams allowed us to identify transitions at distances similar to those indicated by interstellar extinction. In summary, the transition at 550 ± 50 pc seen in the color excess, indicating a subtle cloud that was corroborated by the low values of P≈0.5%, as well as the much sharper transition at 750 ± 50 pc with values between P≈2% and P≈4%. These results allow us to infer the relationship with the Vela Shell in the closest distance and suggest that the distance of the dark cloud [DB2002b] G273.29+2.47 is 800±50 pc.

Resumo. Este estudo faz parte de uma investigação mais ampla que visa mapear o meio interestelar local. O presente trabalho tem como objetivo estudar o número de componentes, a intensidade e a orientação do campo magnético, por meio da polarização (P), o ângulo de polarização(θ) e do excesso de cor $E(b-y)$ avaliados por meio de Diagramas de Polarização por Distância, Diagramas de Excesso de Cor por Distância e Diagramas de Eficiência de Alinhamento P/$E(b-y)$ por Distância. Esses aspectos foram analisados na direção da constelação de Vela, nas proximidades da nuvem escura [DB2002b] G273.29+2.47. Para tanto foram utilizados dados polarimétricos coletados no Observatório do Pico dos Dias (OPD/LNA), utilizando-se o telescópio P&E 1,60 m, no ano de 2023, utilizando o IAGPOL, no filtro V. Tendo em vista os resultados obtidos por Galvão et al. (2024), utilizando Diagramas de Excesso de Cor $E(b-y)$ por Distância, os Diagramas de Polarização por Distância, permitiram identificar transições em distâncias similares às indicadas pela extinção interestelar. Em suma, a transição a 550 ± 50 pc vista no excesso de cor, indicando uma nuvem sutil que foi corrobada pelos baixos valores de P≈0,5%, assim como a transição , bem mais nítida, a 750± 50 pc com valores entre P≈2% até P≈4%. Esses resultados permitem inferir a relação com a Vela Shell na distância mais próxima e sugere que a distância da nuvem escura [DB2002b] G273.29+2.47 é 800±50 pc.

Keywords. ISM: dark clouds – distance – polarimetric – magnetic fields

1. Introduction

Molecular clouds and Bok globules allow us to study star formation in its early stages. Accurate determination of their distances is essential for obtaining absolute physical parameters such as mass, density, and luminosity, allowing us to assess the stability and efficiency of formation. In addition, the three-dimensional location of these clouds in the Galaxy helps identify their interaction with larger structures and correctly interpret polarization, which is used to map the magnetic field. Angarita Y. et al. (2023); Santos F. P. et al. (2011). In this work, a polarimetric study of the interstellar medium in the region around the dark cloud [DB2002B] G273.29+2.47 was performed. This dark cloud is located at the coordinates RA = $09^h36^m44.0^s$ e Dec = $-48°51'54''$, corresponding to Galactic coordinates $l = 273.2959°$ e $b = +2.4738°$. It has been first catalogued Hartley M. et al. (1986) and has a diameter in the sky of 4 arcmin Bica C. M. & Dutra E. (2002). In a previous study, a preliminary distance of 850±50 pc was estimated Galvão M. E. S. et al. (2024). In this study, we sought to refine this distance using polarimetric data.

2. Methodology

The methodology used in this work consists of identifying transitions in polarization and color excess along the line of sight of the cloud, using diagrams of Polarization P, Color Excess E(b-y), Efficiency of Dust Grain Alignment P/E(b-y) as a function of Distance d(pc), according to Santos F. P. et al. (2011); Reis W. & Corradi W. J. B. (2008); Reis W. et al. (2011). For this purpose, polarimetric data were collected at the Pico dos Dias Observatory (OPD) in 2023, using the 1.60 m P&E telescope equipped with the IAGPOL polarimeter, in the V filter. The data reduction was performed using the Solvepol pipeline from IAG/USP Ramírez E. A. et al. (2017), and a complementary catalog was obtained by crossmatching with the StarHorse2 catalog Anders F. et al. (2022). The initial sample contained 383 stars, which was reduced to 308 after the match. The observed area corresponds to 30 arcmin, centered at coordinates RA = $09^h34^m55^s$ and Dec = $-48°38'4''$. The analyzed area and the dark cloud can be seen in Figure 1 with images from Planck R3 HFI (353–545–857 GHz) and DSS2, in the Aladin software. The red square marks the polarimetric field studied, while the blue squares indicate the position of the cloud.

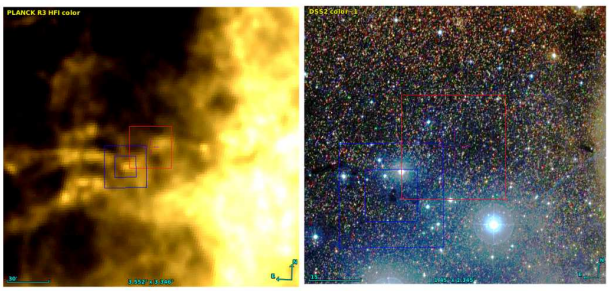

Figure 1. Region viewed in Planck R3 HFI (353–545–857 GHz) and DSS2, with a $30' \times 30'$ red box centered on the target coordinates, and $30' \times 30'$ and $15' \times 15'$ blue boxes centered on the cloud coordinates (adapted from Aladin).

To clean the sample, the following selection criteria were applied: distance less than 2 kpc, Fidelity > 0.5, Flagout < 1, polarimetric signal-to-noise ratio $P/\sigma_p > 3$ and uncertainty $\sigma_p < 0.5\%$.

3. Results

The reduction of data with Solvepol allowed us to obtain the polarization angles of the field studied, shown in Figure 2. It can be seen that the polarization vectors are aligned with the direction of the cloud. In addition, a transition in the size of these vectors can be observed in regions that coincide with dust emission, as shown in Figure 1, seen in Planck R3 HFI (353-545-857 GHz). Next, us-

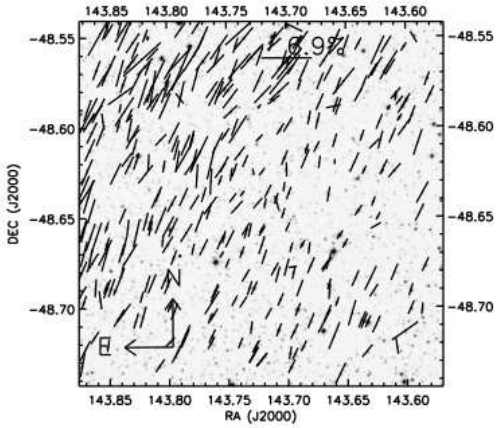

Figure 2. Polarization angles in the observed field after data reduction. Using the Solvepol pipeline

ing TopCat software and cross-referencing the reduced data with the StarHorse2 catalog, diagrams of polarization P, color excess E(b-y), and dust grain polarization efficiency P/E(b-y) were constructed as a function of distance d(pc). These diagrams allowed us to identify transitions at distances similar to those indicated by interstellar extinction in the work of Galvão M. E. S. et al. (2024). In Figure 3, Diagram A shows the polarization degree $P\%$ as a function of the distance d (pc) of the studied field, displaying two significant jumps at 550 ± 50 pc with $P \approx 1 \pm 0.2\%$ and at 800 ± 50 pc with $P \approx 2 \pm 0.5\%$. Diagram B shows $E(b-y)$ versus d (pc) in the same field, revealing the same two jumps. In Diagram C, the ratio $P/E(b-y)$ is presented as a function of distance, with peaks at the same positions, indicating increased alignment at the cloud's location. Diagram D shows $E(b-y)$ versus d (pc)

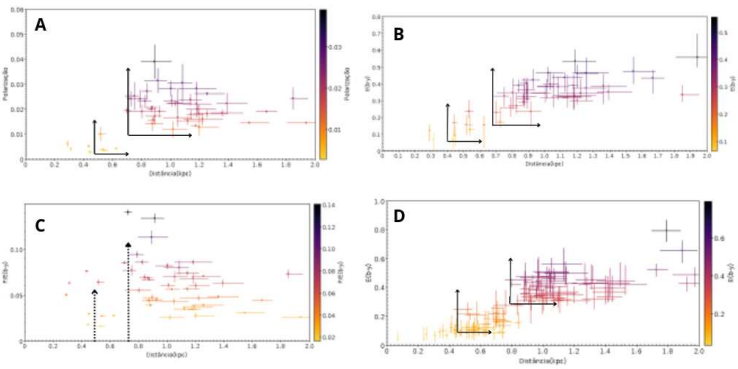

Figure 3. Diagrams of E(b–y), P, and P/E(b–y) as a function of distance. Arrows have been inserted for better visualization of the transitions. (Adapted from TopCat)

specifically for the cloud [DB2002b] G273.29+2.47, also showing jumps at the same distances. The correspondence between the components identified by extinction and by polarization, both in degree and in orientation, reinforces that the spatial structure is strongly shaped by the local magnetic field.

4. Conclusion

The results indicate a relationship with the Vela Shell at the closest distance, observed in the transition at 550 ± 50 pc, with polarization values $P \approx 1 \pm 0.2\%$, considering that the Local Bubble would not extend to that distance (Pelgrims V. et al. 2020). The much clearer transition observed at 800 ± 50 pc, with average polarization values $P \approx 2 \pm 0.5\%$, suggests that this is the distance of the dark cloud [DB2002b] G273.29+2.47, reflecting a significant increase in the alignment of dust grains by the magnetic field. The correspondence between the polarization jumps and the structure identified by the extinction reinforces the idea that the local magnetic field plays a dominant role in the spatial configuration of gas and dust in this region.
The agreement between the methods used validates the estimate obtained and highlights the importance of combined approaches, contributing to the understanding of the local interstellar medium and serving as a basis for future studies on the interaction between dark clouds and the galactic magnetic field. New data are being collected for a more comprehensive mapping of the region.

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