

Distance determination of the dark cloud [DB2002b] G297.33+2.22

L. Santos¹, W. J.B. Corradi², D. Brissi³, N. Sasaki⁴, & W. Reis⁵

¹ IFSP Birigui e-mail: luiz-henrique102@hotmail.com

² LNA e-mail: wbcorradi@lna.br

³ IFSP Birigui e-mail: deidimar@ifsp.edu.br

⁴ UEA e-mail: nsasaki@uea.edu.br

⁵ IBMEC e-mail: wilsonr@fisica.ufmg.br

Abstract. The dark cloud [DB2002b] G297.33+2.22 has been catalogued by Hartley *et al.* (1986) and had its diameter and central coordinates revised by Dutra e Bica (2002), who estimated its diameter in the sky as 3 arcmin. Located in the same region, and apparently associated it can be found the dark cloud TGU H1834, also known as PGCC G297.05+02.31. Its distance was estimated at 920 ± 73 pc using extinction in near-infrared data from the Planck Collaboration (2016). As well, the dark cloud PGCC G297.52+02.03, however no distance determination has been found in the literature. The aim of this work is to estimate the distance to these three dark clouds. Following the method of Reis & Corradi (2011), data from the Starhorse catalogue (Anders *et al.* 2022) have been used to construct reddening spatial distribution maps and colour excess $E(b-y)$ vs. distance $D(pc)$ diagrams, from where sudden jumps in colour excess indicate the distance to the cloud. The analysis has revealed that [DB2002b] G297.33+2.22 is located at 925 ± 40 pc, TGU H1834 at 940 ± 40 pc and PGCC G297.52+2.03 at 880 ± 40 pc from the Sun. These results suggest that the three clouds may be associated. In the future, we intend to use the polarimetric data, collected at the Pico dos Dias Observatory (LNA/Brazil) to improve the understanding of the interstellar medium components in this region.

Resumo. A nuvem escura [DB2002b] G297.33+2.22 foi catalogada por Hartley *et al.* (1986) e teve seu diâmetro e coordenadas centrais revisadas por Dutra e Bica (2002), que estimaram seu diâmetro no céu em 3 minutos de arco. Aparentemente associada na mesma região, encontra-se também a nuvem TGU H1834, também conhecida por PGCC G297.05+02.31. Sua distância foi estimada em 920 ± 73 pc utilizando-se dados de extinção no infravermelho próximo do Planck Collaboration (2016). Da mesma forma encontramos a nuvem PGCC G297.52+02.03, mas ainda sem determinação de distância. O objetivo deste trabalho é estimar as distâncias dessas três nuvens escuras. Seguindo o método de Reis & Corradi (2011), dados do catálogo Starhorse (Anders *et al.* 2022) foram usados para construir mapas da distribuição espacial do avermelhamento e Diagramas de Excesso de Cor $E(b-y)$ por Distância $D(pc)$, a partir do qual transições no excesso de cor, que formam um degrau na direção das estrelas ao longo da linha de visada da nuvem, permitem determinar a distância da nuvem. Os resultados mostram que [DB2002b] G297.33+2.22 está localizada a 925 ± 40 pc, TGU H1834 a 940 ± 40 pc e PGCC G297.52+2.03 a 880 ± 40 pc do Sol. Estes resultados também sugerem que as duas nuvens podem estar associadas. No futuro, pretendemos, utilizar os dados polarimétricos coletados no Observatório do Pico dos Dias (LNA/Brasil) para melhorar o entendimento do meio interestelar nessa direção.

Keywords. ISM: clouds – dust – extinction – distance

1. Introduction

The goal of this project is to investigate the components of the interstellar medium in the direction of the dark cloud [DB2002b] G297.33+2.22 (Fig. 1), which has been catalogued by Hartley *et al.* (1986) and had its diameter determined as 3 arcmin. Its coordinates have been revised by Dutra e Bica (2002), who dubbed it [DB2002b] G297.33+2.22. Apparently associated in the same region are also the TGU H1834 dark cloud, also known as PGCC G297.05+02.31. Its distance has been estimated as 920 ± 73 pc using extinction in near-infrared data from the Planck Collaboration (2016). In the same area one can also find the PGCC G297.52+02.03 dark cloud. However, it still lacks a distance determination.

2. Methodology

To define the distance to the dark clouds, data from the Gaia EDR3 mission, made available through the Starhorse catalog (Anders *et al.*, 2022) has been used. The visual absorption A_V has been used to derive the Strömgen $E(b-y)$ colour excess, by using $A_V = 4.3E(b-y)$ (Strömgen, 1966). To this purpose, the following procedures have been performed:

1. The central coordinate of the molecular cloud [DB2002b] G297.33+2.22 was adopted as right ascension RA = 12h06m16s and declination DEC = -60°09'12" (*e.g.* Dutra and Bica, 2002).
2. Data from the Starhorse catalog were extracted for a region of 25 arcmin radius around the central coordinate.
3. For better reliability of the results, a selection (“cleaning”) criterias has been applied to eliminate data with low quality. According to the parameters defined by the catalog, data were removed from the sample when:
 - distance above 2 kpc;
 - $E(b-y)$ negative;
 - fidelity lower than 0.5;
 - FlagOut greater than or equal to 1;
 - fractional error above 15% in the distance;
 - uncertainty greater than 0.020 mag in the colour excess.
4. Reddening spatial distribution map $E(b-y)$, encoded by the values of the interstellar reddening.
5. Colour excess $E(b-y)$ vs. distance (d) diagram. An auxiliary colour scale, based on the colour excess $E(b-y)$, has used to visualize the position of the stars as a function of reddening.
6. To construct the error bars, P05 and P95 have been used.

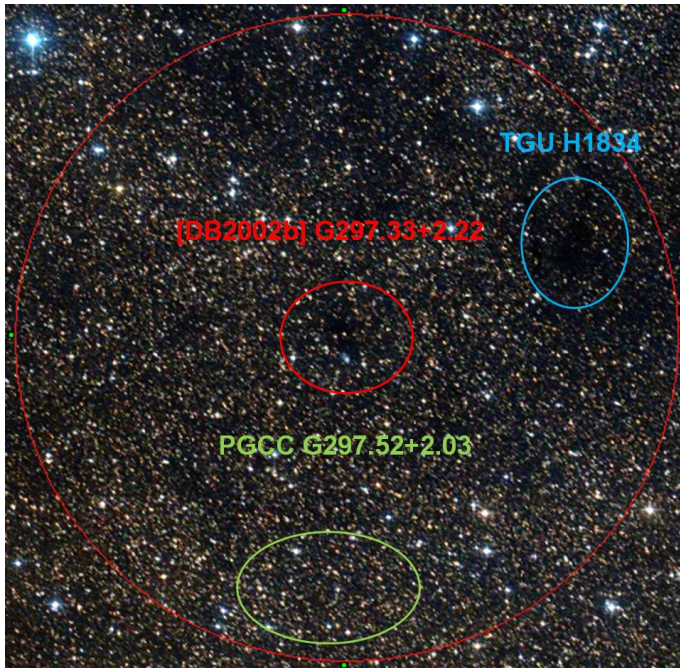


FIGURE 1. Clouds [DB2002b] G297.33+2.22 (center) and TGU H1834 (upper right) and PGCC G297.52+2.03 (below), all in visible (DSS2).

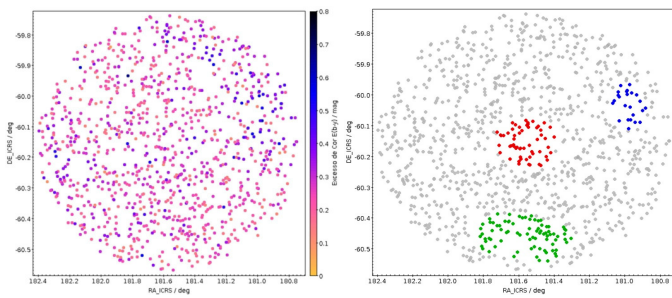


FIGURE 2. (left) Map of the Reddening Spatial Distribution (auxiliary color scale, based on the colour excess $E(b-y)$) and (right) Position of the three clouds in the sky

3. Results

Analysing the Colour Excess vs. Distance Diagrams, together with the Reddening Spatial Distribution Maps, it has been found a minimum $E(b-y) = 0.10$ mag after 100pc, indicating that the interface of the Local and Loop I Bubbles (e.g. Reis *et al.* 2011) has been crossed, and permeates the entire region.

A sudden increase in the colour excess can be seen at $d = 550 \pm 40$ pc, where $E(b-y) = 0.20$ mag, indicating that there is a second component throughout the region. To better investigate this finding, the sample has been separated into four parts to refine distance determinations (Fig. 2 and Fig. 3). The symbols are as follows: [DB2002b] G297.33+2.22 (red dots), TGU H1834 (blue dots), PGCC G297.52+2.03 (green dots) and cloudless regions (gray dots).

For [DB2002b] G297.33+2.22 the step in the colour excess vs. distance diagram occurs at the distance of 925 ± 40 pc.

TGU H1834 presents the step at 940 ± 40 pc. TGU H1834 extends above and to the left in the surveyed area.

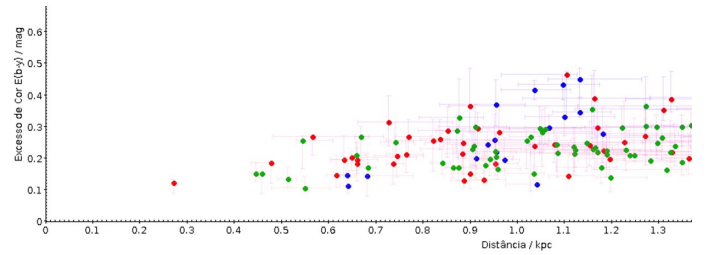


FIGURE 3. Colour excess $E(b-y)$ vs. distance (d) diagram for the three clouds.

For PGCC G297.52+2.03, the step occurs at a distance of 880 ± 40 pc, where the maximum $E(b-y)_{\text{maximum}} = 0.30$ mag.

4. Conclusions

The analysis of the colour excess $E(b-y)$ vs. distance diagrams has revealed that:

1. the [DB2002b] G297.33+2.22 is located at 925 ± 40 pc.
2. TGU H1834 is located at 940 ± 40 pc from The Sun, corroborating the previous determination of 920 ± 73 pc (Planck Collaboration 2016).
3. PGCC G297.52+2.03 is located at 880 ± 40 pc with a maximum $E(b-y) = 0.3$ mag.
4. A component of $E(b-y)_{\text{min}} = 0.2$ mag, which covers the entire region, has been identified at 550 ± 40 pc.
5. These results suggest that the three clouds may be associated, since even in regions outside the clouds there is a growth of extinction.

In the future, we intend to use the polarimetric data collected with the telescopes of the Pico dos Dias Observatory (LNA/Brazil), equipped with IAGPOL, in order to improve the understanding of the interstellar medium in this region.

The advantage is that polarization can more accurately detect smaller amounts of interstellar dust. In addition, the orientation of the magnetic field along the line of sight may allow us to impose more restrictive links to the local interstellar medium models.

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