Dust-Reddening Studies Near the Taurus Molecular Cloud

Sathyanarayanan Kuzhikkatt

ABSTRACT--- In this work, we have analysed the dust-reddening, 'E(B-V)', in the Taurus molecular cloud using the commonly and widely accepted all-sky reddening-maps. We have observed that the Schlegel et al. 1998 dust-map as well as Green et al. 2015 dust-map overestimate the reddening in the region and the Planck Collaboration et al. 2014 reddening data is the better candidate to model dust-distribution and thereby studying star-formation processes in the region.

Keywords. Dust-reddening—molecular clouds.

1. INTRODUCTION

Taurus molecular complex (TMC hereafter) is the closest molecular clouds at a heliocentric distance of 140 pc (Kenyon et al. 1994; Lombardi et al. 2010) where star-formation is not only active but happens in quiescent manner (Kenyon Hartmann 1995; Walter Boyd 1991). Partly due to its proximity and partly as a less disturbed cloud, TMC has been an ideal laboratory to study star-formation processes. The region has been studied in fine spectral and spatial detail over the entire electromagnetic spectrum.

Modeling the dust scattered radiation and constraining the dust-grain properties in regions play a very crucial role in understanding the very early stages of star-formation which is still not fully explored. The first step towards achieving correct estimation of dust-scattered radiation is constructing a better dustdistribution model of the molecular cloud regions. In most cases, it has been observed that a significant contribution towards total dust-scattered flux observed from a region comes from multiply scattered photons which are originating beyond the actual cloud complex. So, though we are only interested in dust-scattered radiation from a particular region, we model the entire sky with a convenient/general dust-distribution (Marshall et al. 2006) followed by a detailed/modified dust distribution within the concerned region making use of available dust-reddening maps.

In this work, we have compared the dust reddening values obtained with three all-sky dust maps, namely SFD (Schlegel et al. 1998), Planck (Planck Collaboration et al. 2014) and GSF (Green et al. 2015) maps, in the

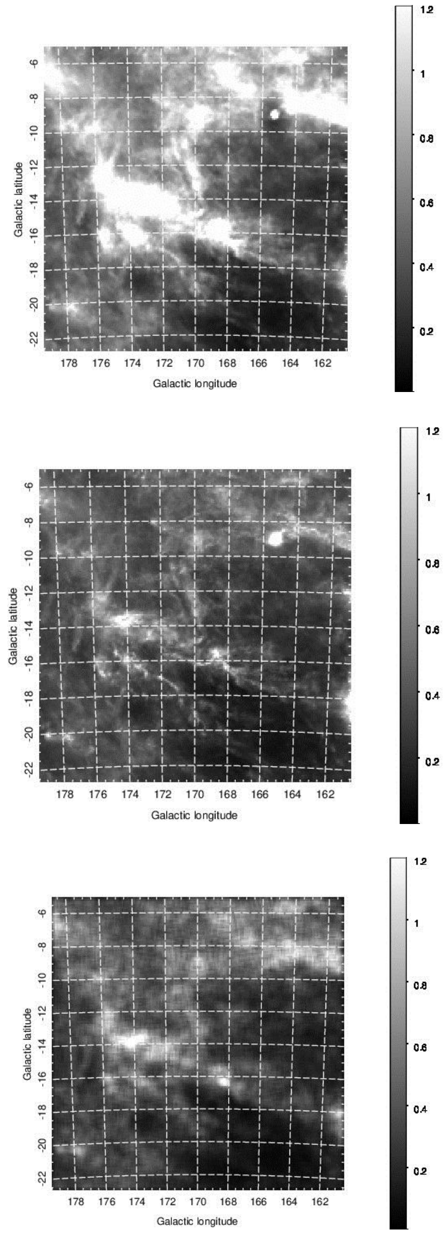

Figure 1. The SFD, Planck and GSF reddening map of the TMC region from top to bottom, respectively. The reddening E(B-V) is expressed in units of mag.

Revised Manuscript Received on December 22, 2018.
Sathyanarayanan Kuzhikkatt Department of Physics, RSM SNDP Yogam college, Kozhikode, Kerala 673305 (Email: sathyanarayank@gmail.com)

Published By: Blue Eyes Intelligence Engineering & Sciences Publication

TMC region. The SFD map is widely used by the astronomy community and has more than 10, 000 citations (NASA ADS website). The Planck dust-map is the latest two-dimensional reddening-map which is available at PLANCK legacy archive (http://pla.esac.esa.int/pla/home). The very recent three dimensional GSF map (the third dimension is the distance) covers three-quarters of the sky. The GSF map is based on Pan-STARRS-1 and 2MASS photometry, and is available at http://argonaut.skymaps.info/. In all the three maps, the dust-reddening 'E(B-V)' is expressed as per the standard definition in units of 'mag'.

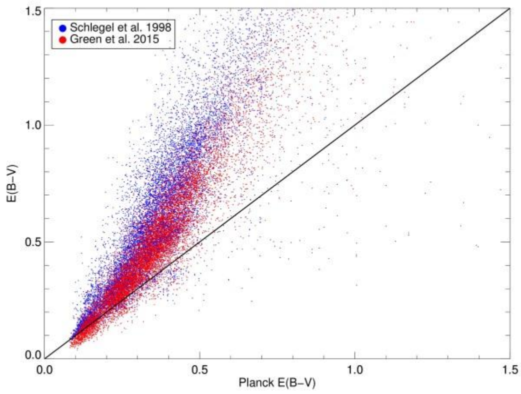

Figure 2. Correlation plot between SFD, PLANCK and GSF reddening.

2. REDDENING DATA

Taurus molecular region lies within the Taurus-Auriga ccloud complex and covers about 100 deg2 in the sky. For the present work, we have selected an area surrounding the (170.0, -14.0) as shown in Fig. 1. The reddening maps of the TMC obtained from all the three dustmaps is shown in Fig. 1. A scatter-plot between the three is also shown in Fig. 2. Note that the GSF map in Fig. 1 is a two-dimensional projection of the actual three-dimensional case. A strong correlation between the three is apparent from Fig. 1 & Fig. 2 but we can note that the values are systematically higher in the case of both SFD and GSF compared with Planck data, especially towards high extinction side.

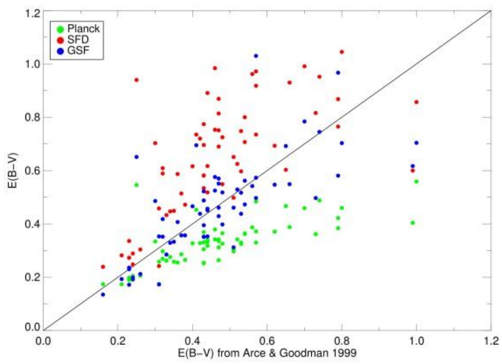

Figure 3. Scatter plot comparing the SFD, PLANCK and GSF reddening with Arce & Goodman (1999) values.

3. RESULTS & ANALYSIS

Arce & Goodman (1999) (AG hereafter) has conducted a detailed dust-extinction analysis of this particular region using four different approaches. All of the methods yield more or less similar results and hence their observations are quite reliable. But since AG observations were limited in number, it is not possible to use these data to study larger regions of the TMC as in our case. Here, we have used the AG results as a check to the reliability of the above mentioned dust-maps. AG has observed that the SFD value may be an overestimate of the actual reddening by a factor of about 1.3 to 1.5 especially in thick molecular regions like TMC where extinction will be high (AV > 0.5). We have not only verified this observation but finds that the correlation between the AG and SFD in the TMC region is very poor (0.60) suggesting that the widely used SFD map is not a good alternate to study molecular regions at-least the TMC. At the same time, a strong correlation of 0.82 between the Planck and AG suggests the former is a better option over the SFD. The correlation plot is shown in Fig. 3.

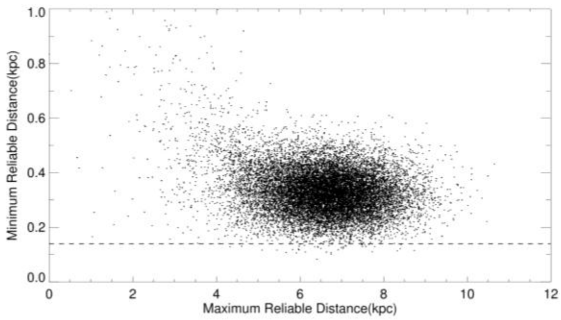

Figure 4. Minimum and maximum reliable distance as a quality to check to GSF data in Taurus region. The dashed line represents the distance (140 pc) to the front-face of the cloud.

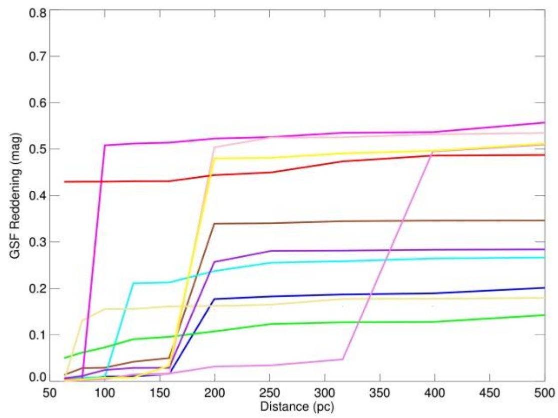

Figure 5. GSF dust distribution as a function of helio-centric distance along various line of sights (randomly selected) in the TMC region.

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

We have further done a comparison analysis between the Planck and the GSF data though we have observed that there exists a weak correlation (0.67) between the AG and GSF. Since the Planck values are mean of about 5 arc-second beam and the GSF data are are along particular lines of sight, hence an overestimate of the reddening in the GSF data may be an indicator of clumpiness in the Taurus region (Panopoulou et al. 2014). But the 'maximum and minimum reliable distance' quality parameter (as described in Green et al. 2015) for most of the line of sights in the TMC (Fig.4) suggests that the reddening values obtained from the GSF map may not be reliable. This may be the reason for significant foreground dust distribution ($\leq$ 140 pc) along a number of line of sights in the TMC region as per the GSF data (Fig. 5) which is inconsistent with the presence of the local bubble. It can also be pointed out that the dust-distribution in the region is somewhat different from expected as the general consensus is that there is no much dust either in-front or behind the TMC cloud such that distance to the front-face of cloud is 140 pc and the cloud thickness is 20 pc (Padoan et al. 2002). Thus we suggests that the Planck data is a better option over the GSF as well to model dust-distribution in the TMC region.

4. CONCLUSION

We have studied dust-reddening values in the TMC complex obtained from the SFD, Planck and GSF dustmaps. We find that the Planck data matches well with AG studies and is better candidate over both the SFD and the GSF maps. The SFD map is not reliable in high extinction regions while the quality parameter check is very essential prior to implement GSF data in any regions.

5. ACKNOWLEDGEMENTS

Sathyanarayan would like to thank Prof. Jayant Murthy for his guidance. The dust extinction map obtained from PLANCK (http://www.esa.int/Planck), an ESA science mission with instruments and contributions directly funded by ESA Mem ber States, NASA, and Canada.

REFERENCES

1 Arce H. G., Goodman A. A., 1999, ApJ, 517, 264
2 Green G. M., Schlafly E. F., Finkbeiner D. P., Rix H.-W., Martin N., Burgett W., Draper P. W., Flewelling H., Hodapp K., Kaiser N., Kudritzki R. P., Magnier E., Metcalfe N., Price P., Tonry J., Wainscoat R., 2015, ApJ, 810, 25
3 Kenyon S. J., Dobrzycka D., Hartmann L., 1994, AJ, 108, 1872
4 Kenyon S. J., Hartmann L., 1995, ApJS, 101, 117
5 Loinard L., Mioduszewski A. J., Rodrguez L. F., Gonzalez R. A., Rodrguez M. I., Torres R. M., 2005, ApJ, 619, L179
6 Lombardi M., Lada C. J., Alves J., 2010, AA, 512, A67
7 Padoan P., Cambresy L., Langer W., 2002, ApJ, 580, L57
8 Planck Collaboration Abergel A., Ade P. A. R., Aghanim N., Alves M. I. R., Aniano G., Armitage-Caplan C., Arnaud M., Ashdown M., Atrio-Barandela F., et al. 2014, AA, 571, A11
9 Schlegel D. J., Finkbeiner D. P., Davis M., 1998, ApJ, 500, 525
10 Walter F. M., Boyd W. T., 1991, ApJ, 370, 318