3D extinction mapping of the Milky Way with the Besançon Galaxy Model in the Gaia era

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Summary: The structure of the Milky Way (MW) disc remains poorly constrained in spite of numerous studies. The challenge comes from the fact that we are inside the MW, which makes all structures overlap along the line of sight. It is then needed to disentangle those structures to get a clear view of our Galaxy. 3D extinction maps aim to characterize the distribution of dust within our Galaxy, as well as to provide information about the structure of the MW by unveiling the position and shape of interstellar medium (ISM) objects. By improving our knowledge on the current structure of the MW, we can better understand the formation and evolution of our Galaxy, as well as stellar formation. Recent studies usually provide detailed 3D extinction maps, but that only extend to a few kiloparsecs or do not cover the entire Galactic plane (Chen et al. (2019), Green et al. (2019), Leike et al. (2022), Lallement et al. (2022) to cite a few).

We present a new method to map the interstellar extinction of the MW in 3D. This method is based on a Markov Chain Monte Carlo algorithm coupled with Bayesian inference. By comparing the colour distribution of stars between a stellar population synthesis model, the Besançon Galaxy Model (BGM), and observations from 2MASS and Gaia DR3 for a specific line of sight, one estimates the dust distribution along it, assuming that extinction is the only difference between the model and observations. To constrain the distance to near objects even better, Gaia parallaxes can also be used. It is then possible to create 3D extinction maps by repeating this process for many lines of sight.

While Gaia observes in the visible domain, 2MASS observed in the near-infrared (NIR) domain. The interstellar extinction being much lower in the NIR, 2MASS data allow us to probe deeper into the MW disc, while Gaia data helps to improve the precision of our maps closer to the Sun, especially thanks to the parallaxes. The combination of both datasets should then allow us to map the 3D dust distribution at all scale while keeping a reasonable amount of details. We shall present some examples of applications of this method towards well known structures for validation.

References

Chen, B-Q et al. (Mar. 2019). "Three-dimensional interstellar dust reddening maps of the Galactic plane." In: *Monthly Notices of the Royal Astronomical Society* 483.44, pp. 4277–4289. DOI: 10.1093/mnras/sty3341.

Green, Gregory M. et al. (Dec. 2019). "A 3D Dust Map Based on Gaia, Pan-STARRS 1, and 2MASS." In: *The Astrophysical Journal* 887.11. DOI: 10.3847/1538-4357/ab5362.

Leike, R. H. et al. (Apr. 2022). "The Galactic 3D large-scale dust distribution via Gaussian process regression on spherical coordinates." In: *arXiv e-prints*. DOI: 10.48550/arXiv.2204.11715.

Lallement, R. et al. (May 2022). "Updated Gaia-2MASS 3D maps of Galactic interstellar dust." In: *Astronomy & Astrophysics* 661. DOI: 10.1051/0004-6361/202142846.