Computational Intelligence for Multimodal Astrophysical Tomography

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ABSTRACT

Our Galaxy is permeated by a large-scale magnetic field, which plays an integral role in a wide range of astrophysical processes, including star formation, high-energy astrophysics, and cosmology. A detailed mapping of the Galactic magnetic field would revolutionize our understanding of these phenomena. However, our diagnostics of astrophysical magnetic fields are few, hard to obtain, and difficult to process. One major diagnostic of the magnetic field properties is starlight polarization. Starlight usually starts out unpolarized, and picks up polarization through partial absorption by magnetized interstellar dust. This polarization retains “memory” of interstellar magnetic fields, and it can thus be used as a magnetic field probe. For this reason, large starlight polarization surveys are currently underway by researchers in the Institute of Astrophysics (FORTH-IA) (co-I K. Tassis is the PI of the largest such survey ever performed, PASIPHAE, that will measure the polarization of over a million stars) [1]. Combining such stellar polarization data with the distances of the stars determined by ESA’s Gaia mission one can in principle reconstruct the 3D geometry of the magnetic field that permeates our Galaxy. The problem is similar to that of the tomographic mapping of the human body used in medical imaging but it suffers from the sparsity of the available data due to the given distribution of stars making it significantly more challenging

A second major problem is that the observed starlight polarization does not always originate entirely in interstellar absorption. An appreciable fraction of stars emits partially polarized light. These intrinsic polarizations are a nuisance for Galactic magnetic field studies since they increase the noise of the observed polarization measurements, but also a real treasure for stellar astrophysics. It is thus absolutely essential to develop a robust strategy for identifying such stars based on multimodal data: polarization itself; stellar spectra; stellar luminosities; and probes of stellar environments. So far, the existing techniques used by astronomers have not been sufficient to resolve the problem of identifying intrinsically polarized stars, and the subject of intrinsic stellar polarizations is vastly underexplored. In the era of large, complex, multimodal polarization datasets, the need for high-performance automated computational tools for addressing these challenges is inevitable. To that end, in the context of this project there will be developed and evaluated an integrated computational intelligence framework for astrophysical tomography.

REFERENCES

[1] Tassis, K., Ramaprakash, A. N., Readhead, A. C. S., et al. 2018.PASIPHAE: A high-Galactic-latitude, high-accuracy optopolarimetric survey. arXiv:1810.05652