Polarization Measurement Analysis

The polarization of astrophysical signals is a field of study that has seen much progress over recent years, in particular with the release of the first complete survey of the polarized microwave sky by the Planck satellite.

The linear polarization of electromagnetic radiation is usually represented, and actually measured, in terms of Stokes parameters (Q and U), but astrophysical models aiming to explain the physical origin of such a polarized emission do so in terms of its intensity P and its direction in the plane of the sky. The relationship between the two descriptions is non-linear, so that random errors in the measurements of Q and U translate to a positive statistical bias on P. This means that, given a very large ensemble of measurements of Q and U towards the same line of sight, the average value of P derived from these will systematically by overestimated. The problem becomes even more acute when the signal-to-noise ratio is low, and when only few independent measurements are available.

We have developed a statistical framework (Polarization Measurement Analysis) to deal with these issues, and the results have been put to use within the Planck collaboration (Plaszczynski et al. 2014, Montier et al. 2015a, Montier et al. 2015b, Alina et al. 2016). We are in the process of making this framework available to a wider community, with the aim of providing astrophysicists new to the analysis of polarization data the necessary easy-to-use tools to correctly interpret their data.

The PMA Library is a set of IDL and python routines which implement this framework, the IDL tools being developed at IRAP (Toulouse), most notably by L. Montier, and the python tools being developed by F. Levrier at LERMA (Paris). The work proposed in this internship is twofold :

1/ First, the intern will help contribute to the PMA Library by implementing the Bayesian approach in the python side of the Library, and ensuring that the IDL and python tools yield identical results.

2/ In a second step, the intern will use the tools to assess polarization properties towards a set of Galactic molecular clouds, using data from the Planck satellite, or if available from the PILOT balloon-borne experiment.

References

- **A novel estimator of the polarization amplitude from normally distributed Stokes parameters** S. Plaszczynski, L. Montier, F. Levrier, M. Tristram, MNRAS, 439, 4048, 2014
- **Polarization measurements analysis I. Impact of the full covariance matrix on the polarisation fraction and angle measurements** L. Montier, S. Plaszczynski, F. Levrier, M. Tristram, D. Alina, I. Ristorcelli, J.-P. Bernard, A&A, 574, 135, 2015
- **Polarization measurements analysis II. Best estimators of the polarization fraction and angle** L. Montier, S. Plaszczynski, F. Levrier, M. Tristram, D. Alina, I. Ristorcelli, J.-P. Bernard, A&A, 574, 136, 2015
- **Polarization measurements analysis III. Analysis of the polarization angle dispersion function with high precision polarization data** D. Alina, L. Montier, I. Ristorcelli, J.-P. Bernard, F. Levrier, A&A, 595, 57, 2016