A First Look at the Interstellar Polarization Survey Database

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A new database

We present a first look at the Interstellar Polarization Survey (IPS) Database. This database contains optical linear polarimetric measurements of over 35.000 stars down to V-mag ~16 obtained using the IAGPOL polarimeter (Magalhaes+05) installed in the Boller & Chivens telescope of Observatório do Pico dos Dias (Brazil). We focus on fields of about 0.3x0.3 degrees in size, located in or close to the Galactic Plane (**Fig. 1**). The polarization of most sources in these fields has an interstellar origin and depends on the distribution and properties of interstellar dust, as well as the Galactic magnetic field (GMF). We aim to use the database to study the GMF through correlations with other interstellar medium (ISM) tracers, analysis of interstellar turbulence, and modeling of dust polarization.

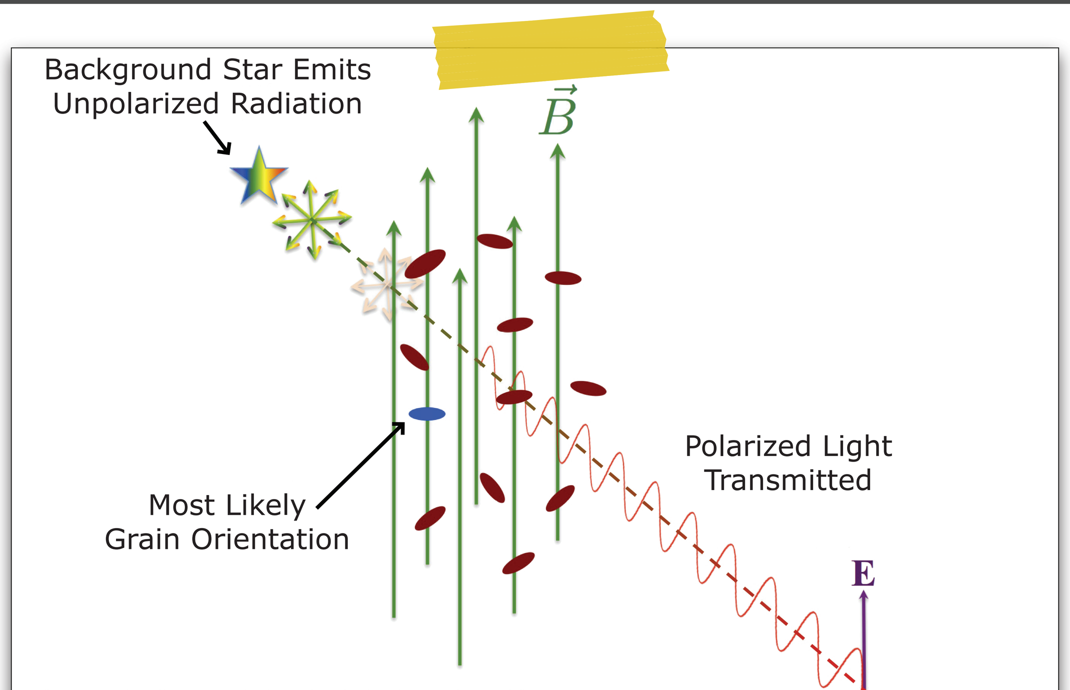

Fig. 2: Grain alignment-induced polarization. Adapted from: http://bganderson.net/grain-alignment

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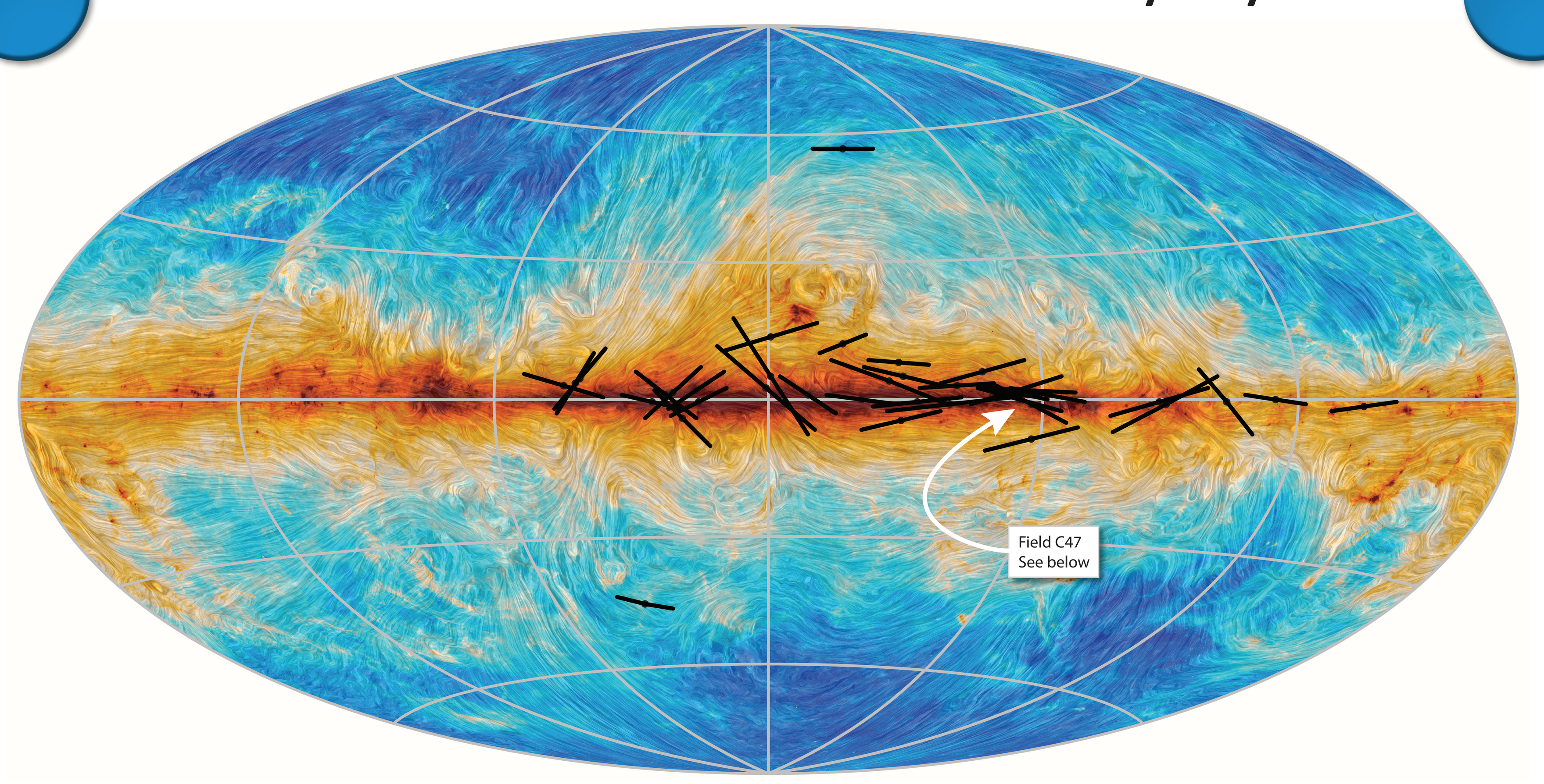
Polarization of observed fields in the Milky Way



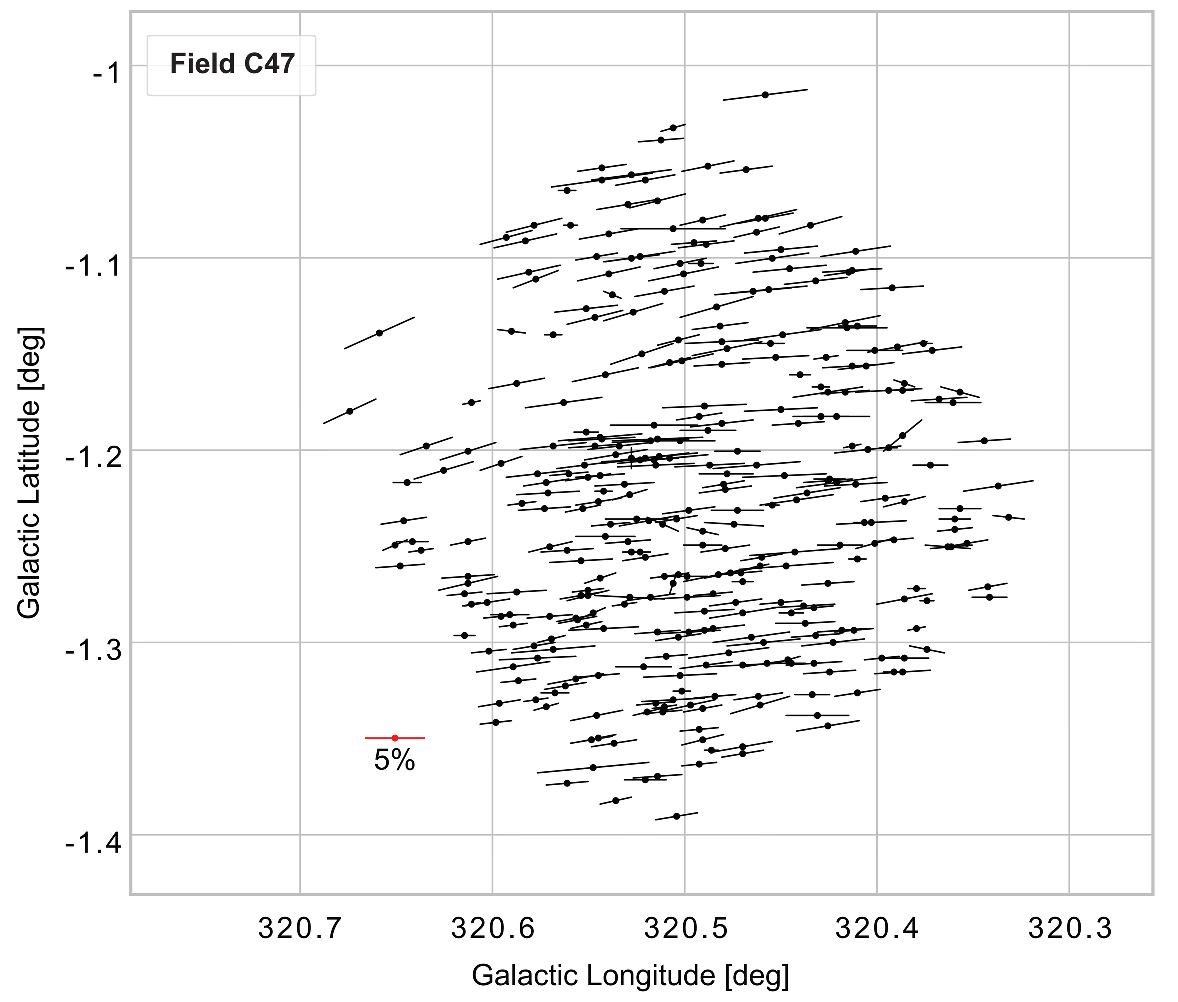


Fig. 1: Top panel: Average polarization for each of the 38 fields in the IPS data. Each polarization vector is the average for that field. Background image: copyright ESA/Planck collaboration, credit Marc-Antoine Miville-Deschênes. **Bottom panel:** Details of one observed field (C47). Each field contains ~900 stars on average.

Filters:

We have applied filters, including:

- $P/\sigma P > 5$
- $d \leq 6$ kpc.

Optical Starlight Polarization

Optical Starlight Polarization is a powerful tool with which to study the ISM. When light from a star passes through the dust in the ISM, the light becomes slightly polarized (Hiltner 49). Due to the alignment of elongated grains to the magnetic field, the position angle of optical polarization is parallel to the magnetic field in the plane of the sky (see e.g. Andersson+15), **Fig. 2**. By studying the polarization of the incoming light, we can learn about the ISM conditions and properties along our line of sight to the star. More specifically, we're interested in studying magnetic fields. Although optical starlight polarization has been used in the past to study magnetic fields in dense portions of the ISM, we are now applying these methods (e.g. Chandrasekhar & Fermi 53) to the diffuse medium in order to study the GMF (see e.g. Jaffe 19). As a GMF tracer, starlight polarization has the unique ability to probe magnetic fields in 3D— by adding distances from GAIA to each measurement, we are able to add a whole new dimension to our understanding of the GMF.

Average P and θ per Lon/Lat bin

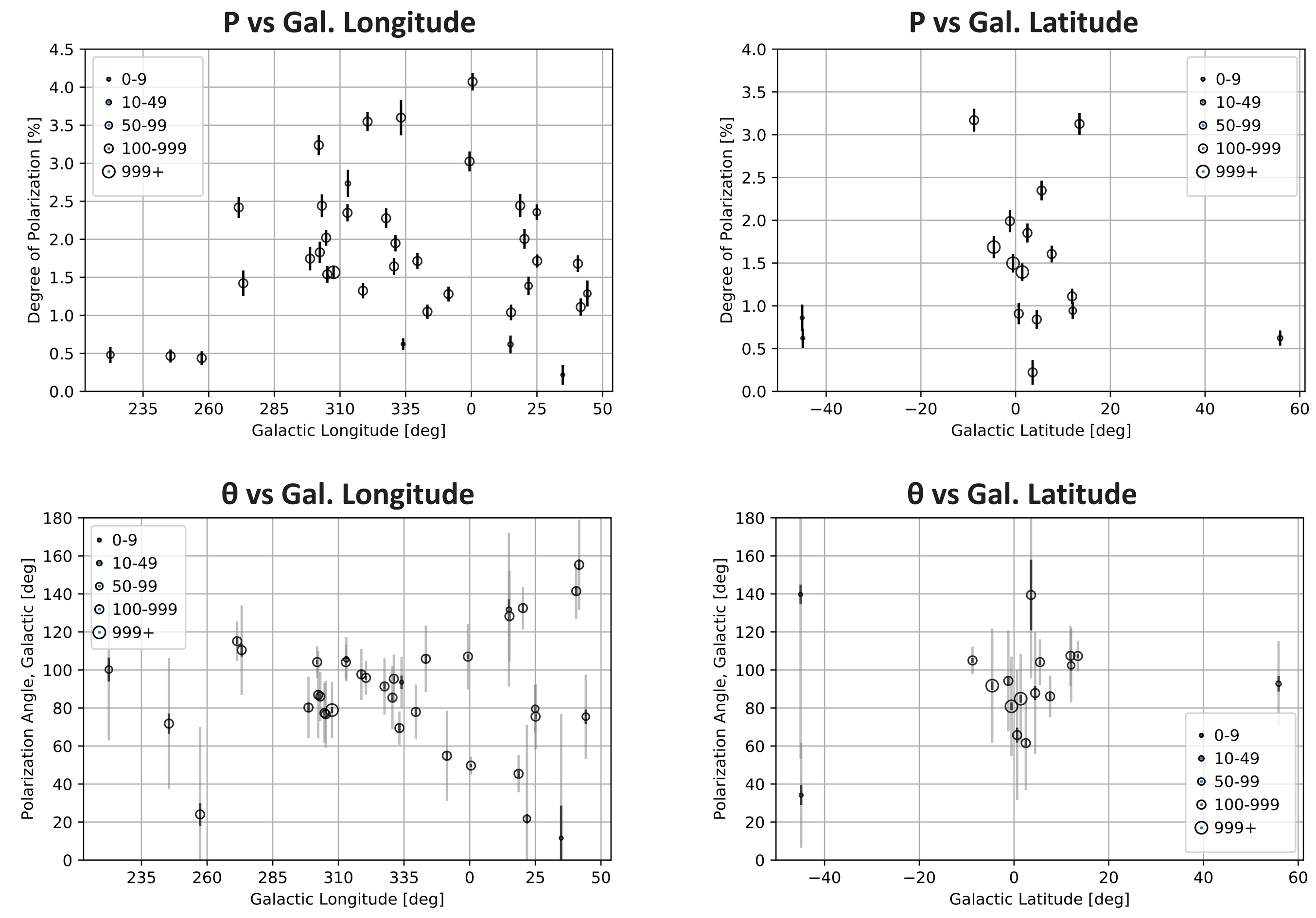


Fig. 3: Degree of polarization (P) and angle of polarization (θ) averaged per 1° longitude/latitude bin. Marker size scales with the number of stars in that bin. Gray error bars denote the standard deviation in that bin. Black error bars represent the average measurement error.

P, θ as a function of distance

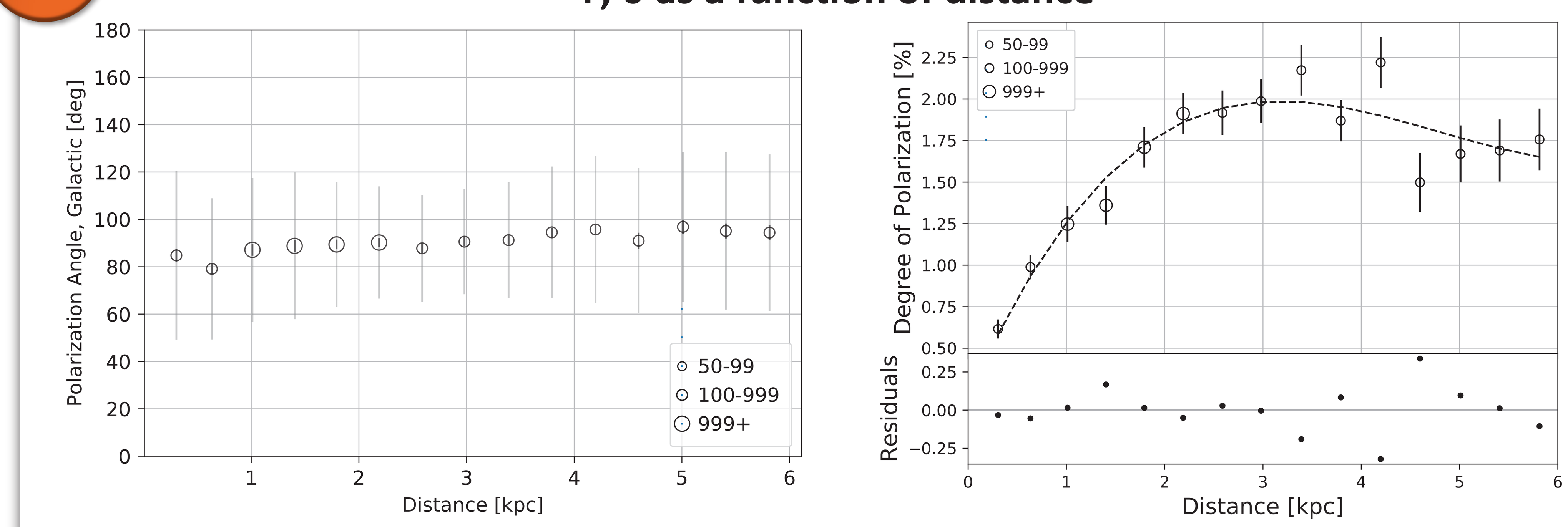


Fig. 4: Polarization angle (**left**) and polarization degree (**right**) as a function of distance. Marker size scales with the number of stars in that bin. **Left panel:** Polarization angle vs distance. Gray error bars denote the standard deviation in that bin. Black error bars are the average measurement error. **Right panel:** Degree of polarization vs distance with a 3rd degree polynomial fit.

Correlations

The degree of polarization is sensitive to the amount of dust along the line of sight. For example, the polarization is higher at lower latitudes (|b| < 15°), closer to the Galactic Plane (**Fig. 3**). The polarization angle is pretty stable throughout all distances, but the degree of polarization changes as a function of distance (**Fig. 4**). We've fitted a 3rd degree polynomial to the data and find $P[\%] = 0.202 + 1.347d - 0.317d^2 + 0.022d^3$. Compare this to Fosalba+02, who did the same with another optical starlight polarization database (Heiles 00) and found $P[\%] = 0.13 + 1.81d - 0.47d^2 + 0.036d^3$. Looks like we're finding a similar trend!

References

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What's next?

- Preparing an article with these first results (Versteeg et al., in prep.).
- Exploring the connections between polarization and extinction/reddening (Angarita-Arenas et al., in prep.).
- Comparing these data to other GMF and dust tracers as in **Fig 1, top**.

We aim to use the IPS database as a new tracer to study the GMF, but a database like this can contribute in many more ways, e.g.:

- ISM studies
- Galactic Foreground studies
- Stellar astrophysics

Statistics:

- Over 35k stars
- Average density of 900 stars per field (0.3x0.3°)
- Gaia DR2 distances

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