The far-infrared polarization spectrum of Rho Ophiuchi A from HAWC+/SOFIA observations

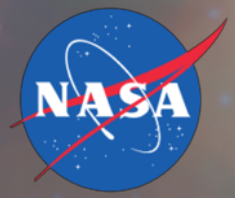
Fabio P. Santos

Post-doctoral Fellow

Max Planck Institute for Astronomy

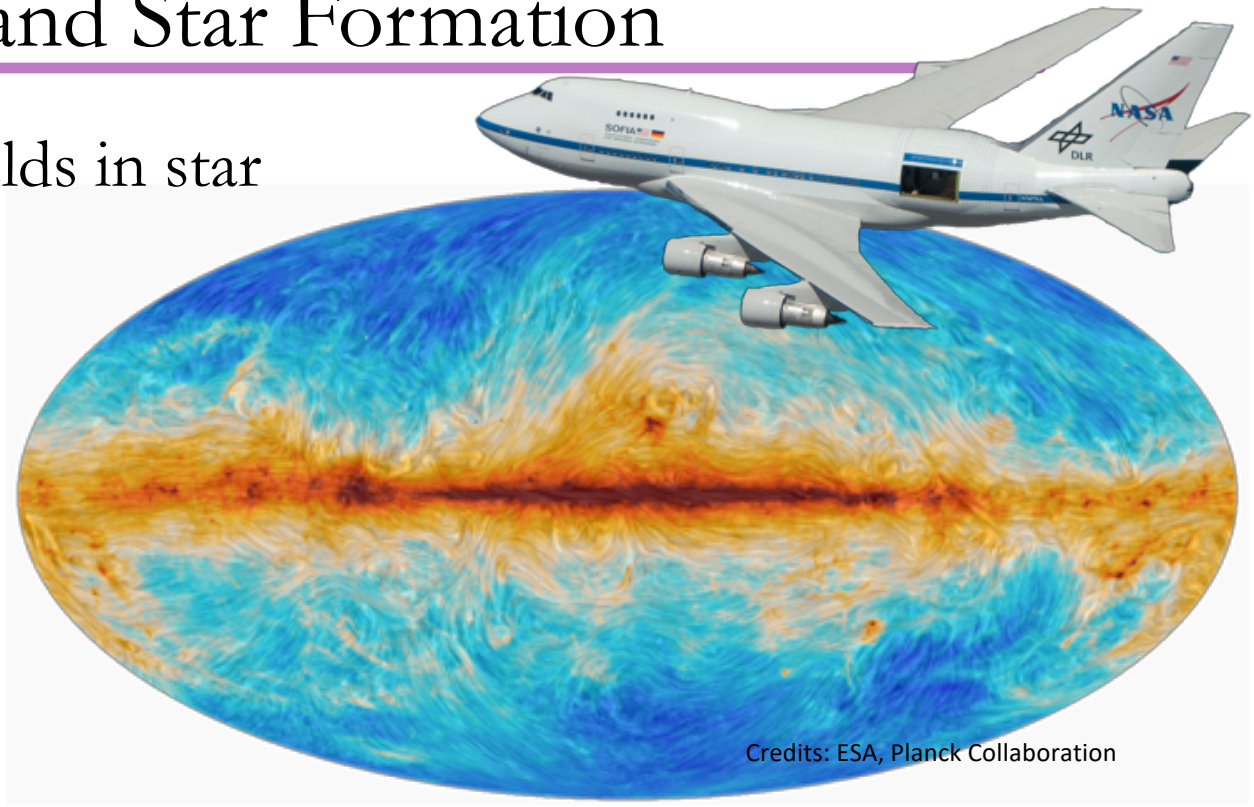
Heidelberg, Germany

Contact: fabiops@mpia.de



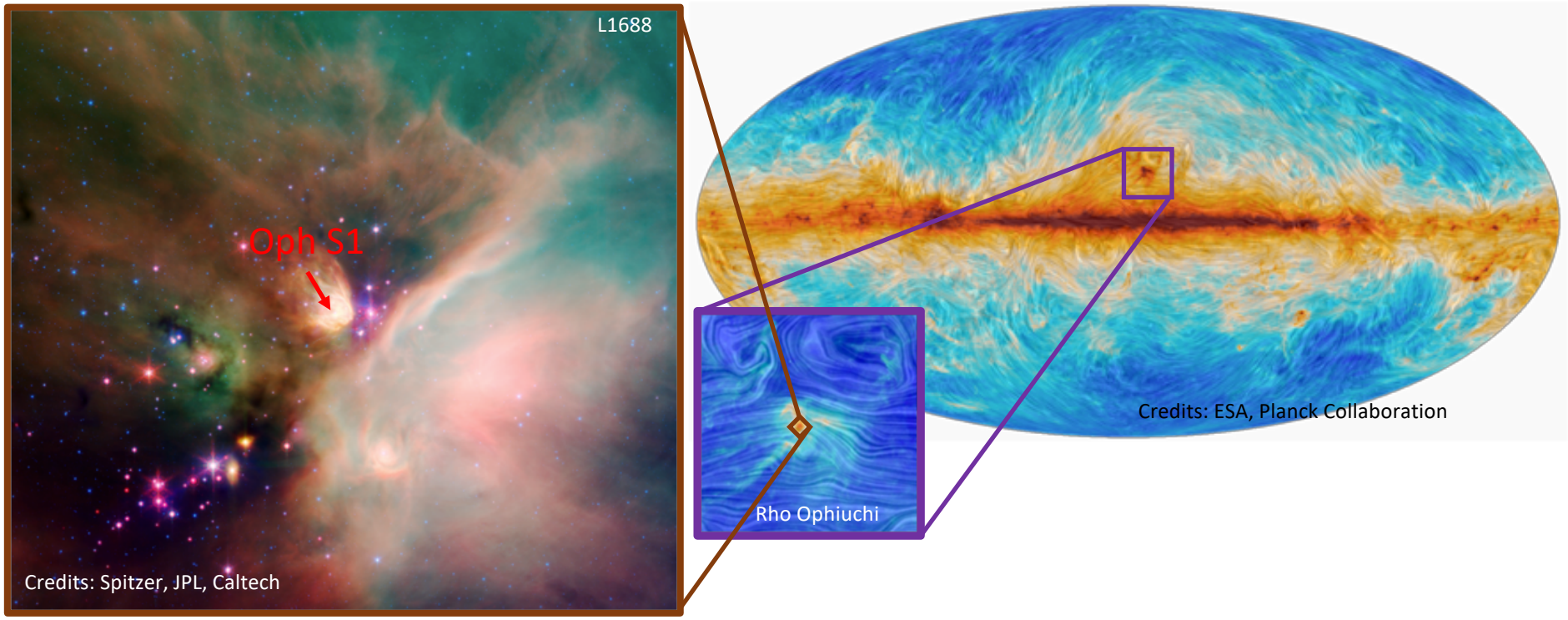
Magnetic Fields and Star Formation

- Role of magnetic fields in star formation
- Interstellar polarization from dust emission
- How to interpret polarization maps? Indirectly traces magnetic fields
  - Grain alignment



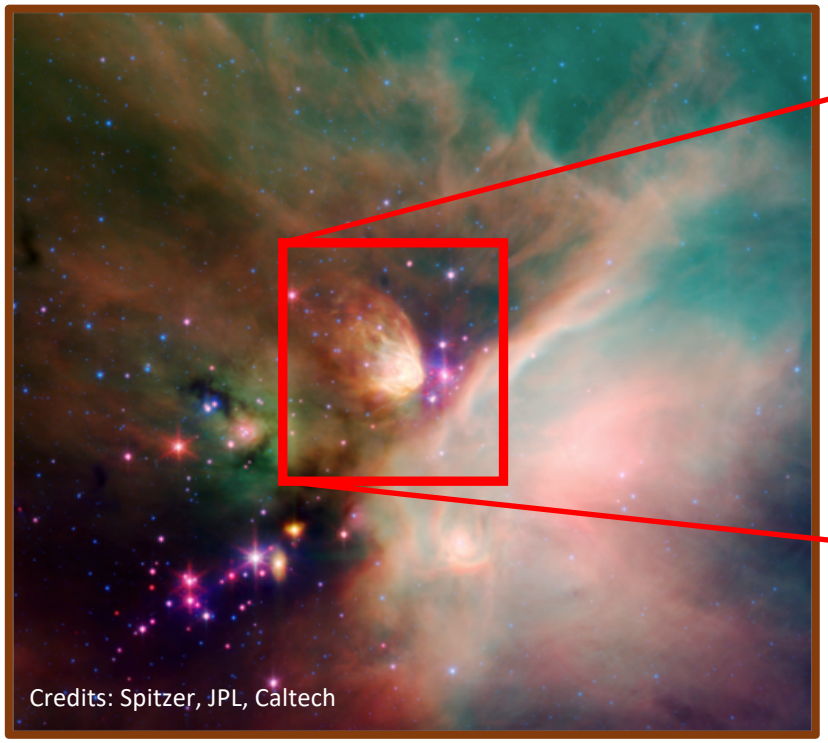
Magnetic fields in the Milky Way mapped through observations of interstellar polarization

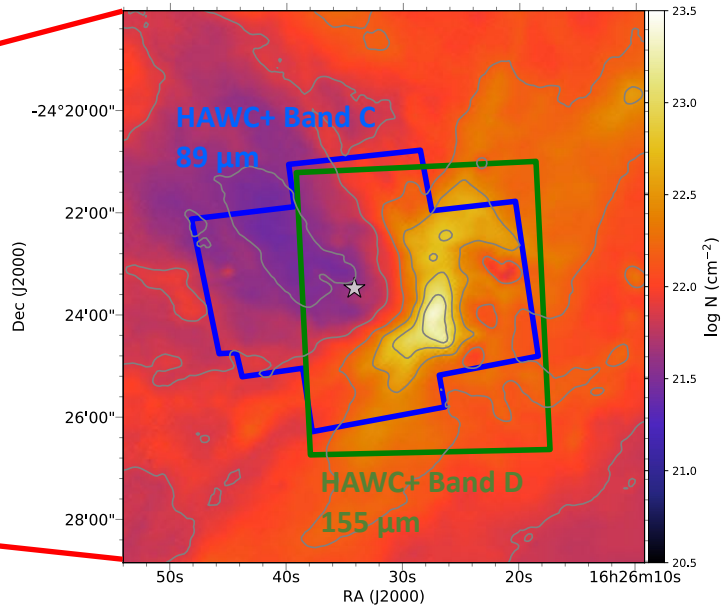
Rho Oph A Molecular Cloud



- Rho Oph A: ~130 pc
- Warmed up by Oph S1 - massive B3 star

Rho Oph A – HAWC+ Observations





Column density map (based on Herschel)

- Peak extinction $A_V > 100$ mag

- HAWC+ Observations:
  - Band C: 89 μm
  - Band D: 155 μm

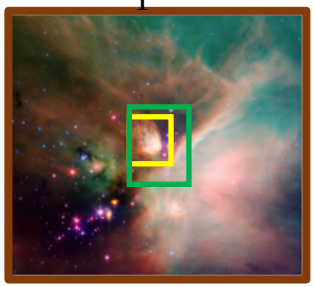
Main Goal: combine pol. bands C and D

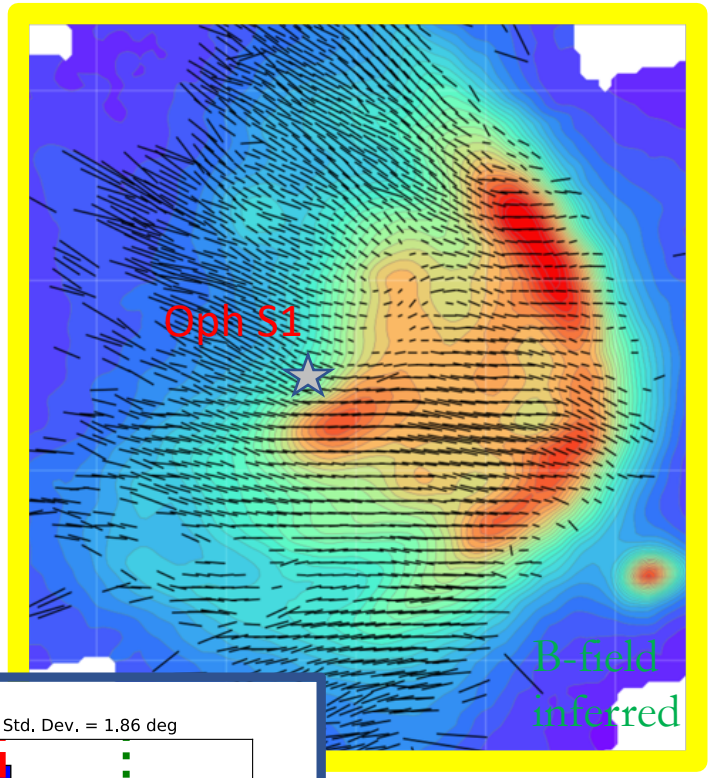
- Slope of polarization spectrum – probe grain alignment efficiency
- Test Radiative Torques (RATs)

Magnetic fields in Rho Oph A

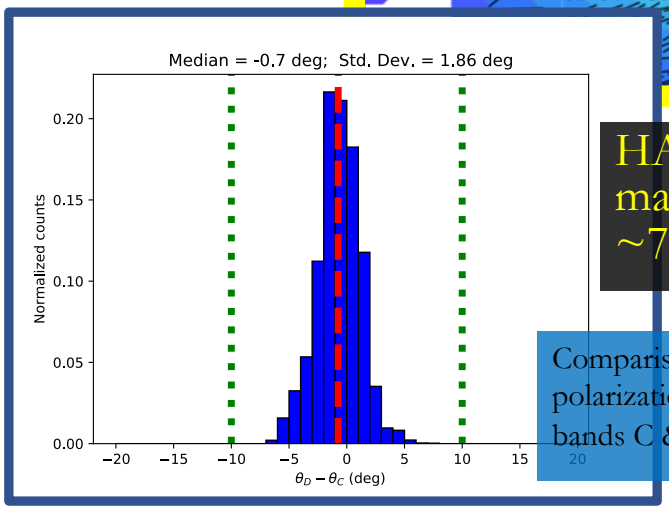
Santos et al. (2019, submitted - ApJ, arXiv: 1905.00705)

Rho Oph A

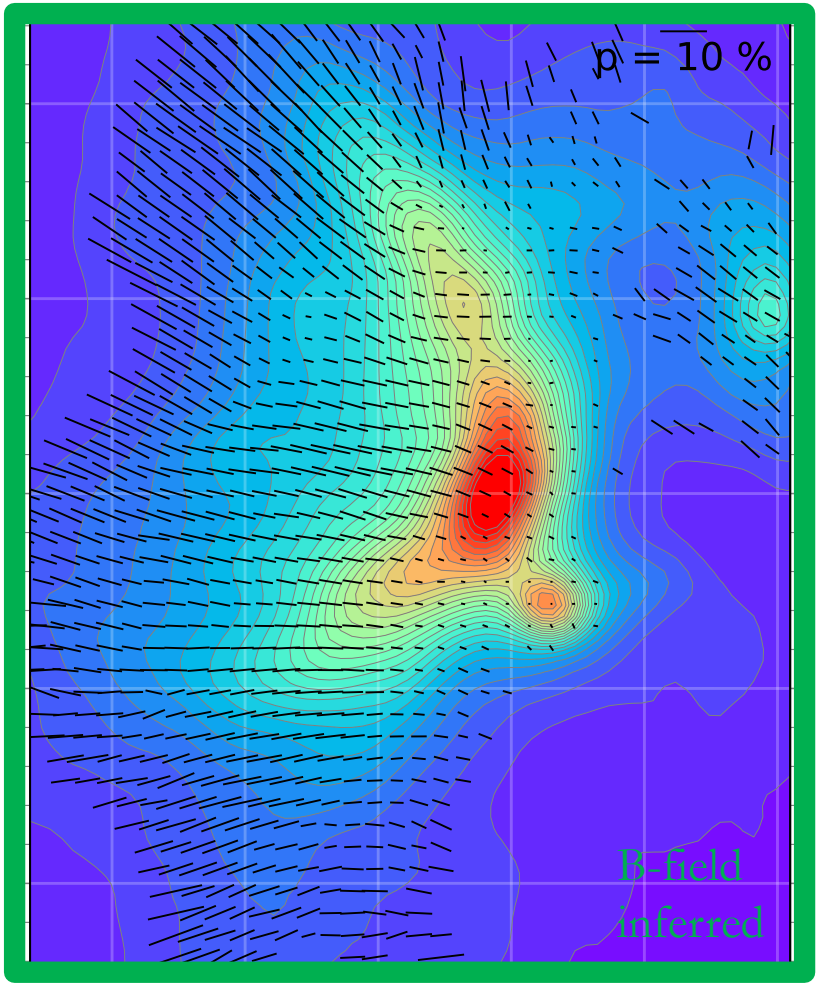




HAWC+ polarization map band C - 89 μm, ~7.8" beam size



Comparison of polarization angles bands C & D

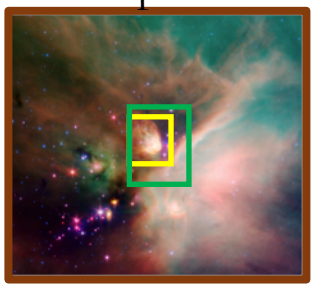


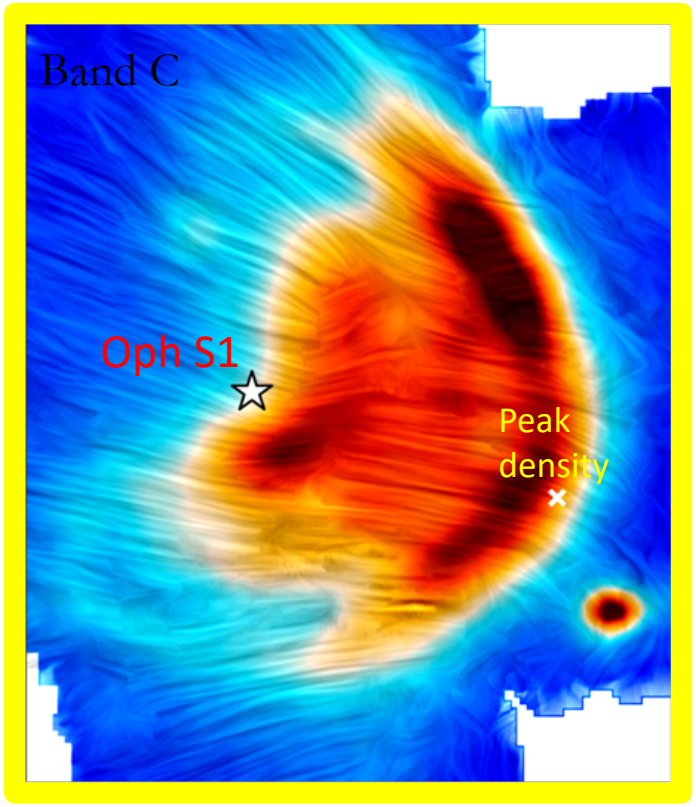
HAWC+ polarization map band D - 155 μm, ~13.6" beam size

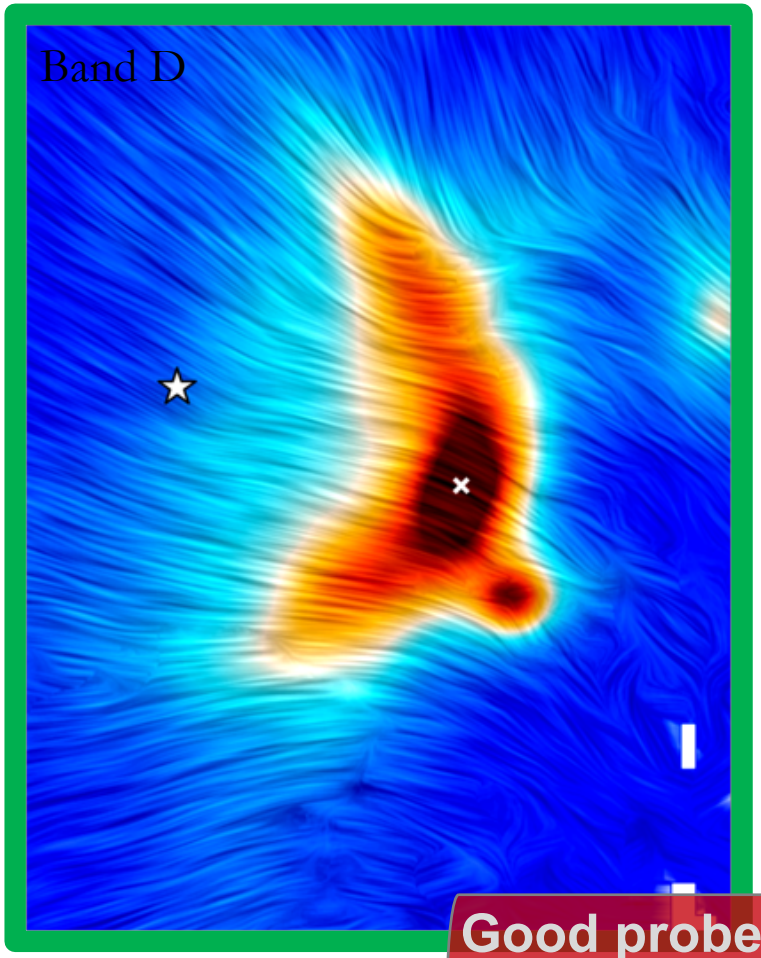
Magnetic fields in Rho Oph A

Santos et al. (2019, submitted - ApJ, arXiv: 1905.00705)

Rho Oph A







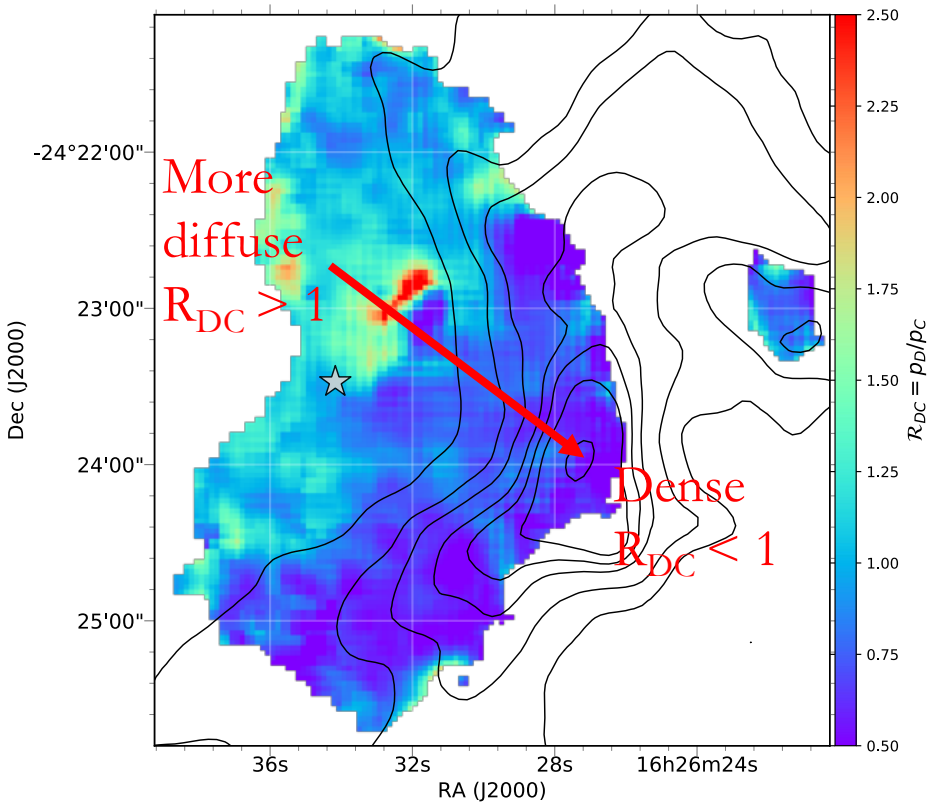
- Slope of polarization spectrum: $R_{DC} = P_D / P_C$

Good probe of grain alignment efficiency

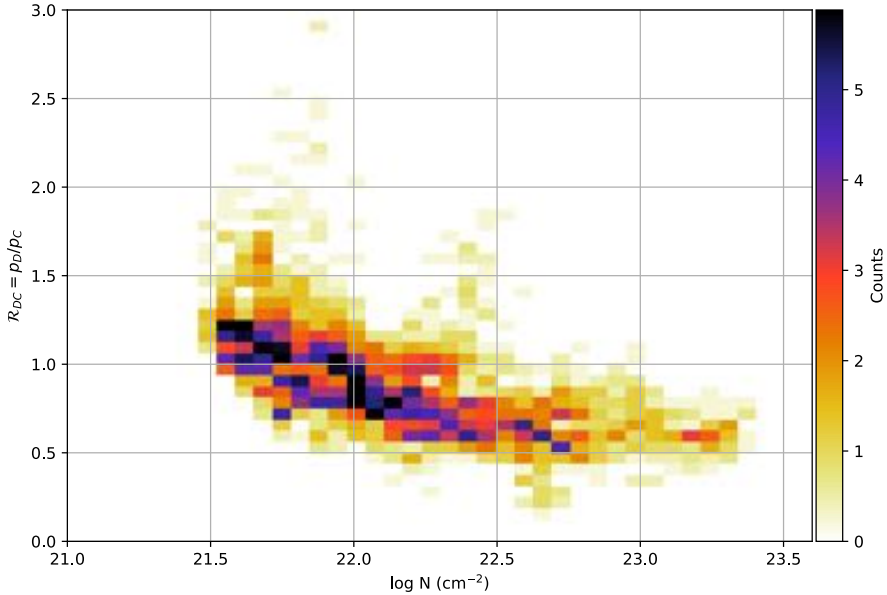
Far-IR polarization spectrum

Santos et al. (2019, submitted - ApJ, arXiv: 1905.00705)

Map of $R_{DC} = P_D / P_C$



R_{DC} as a function of column density log N



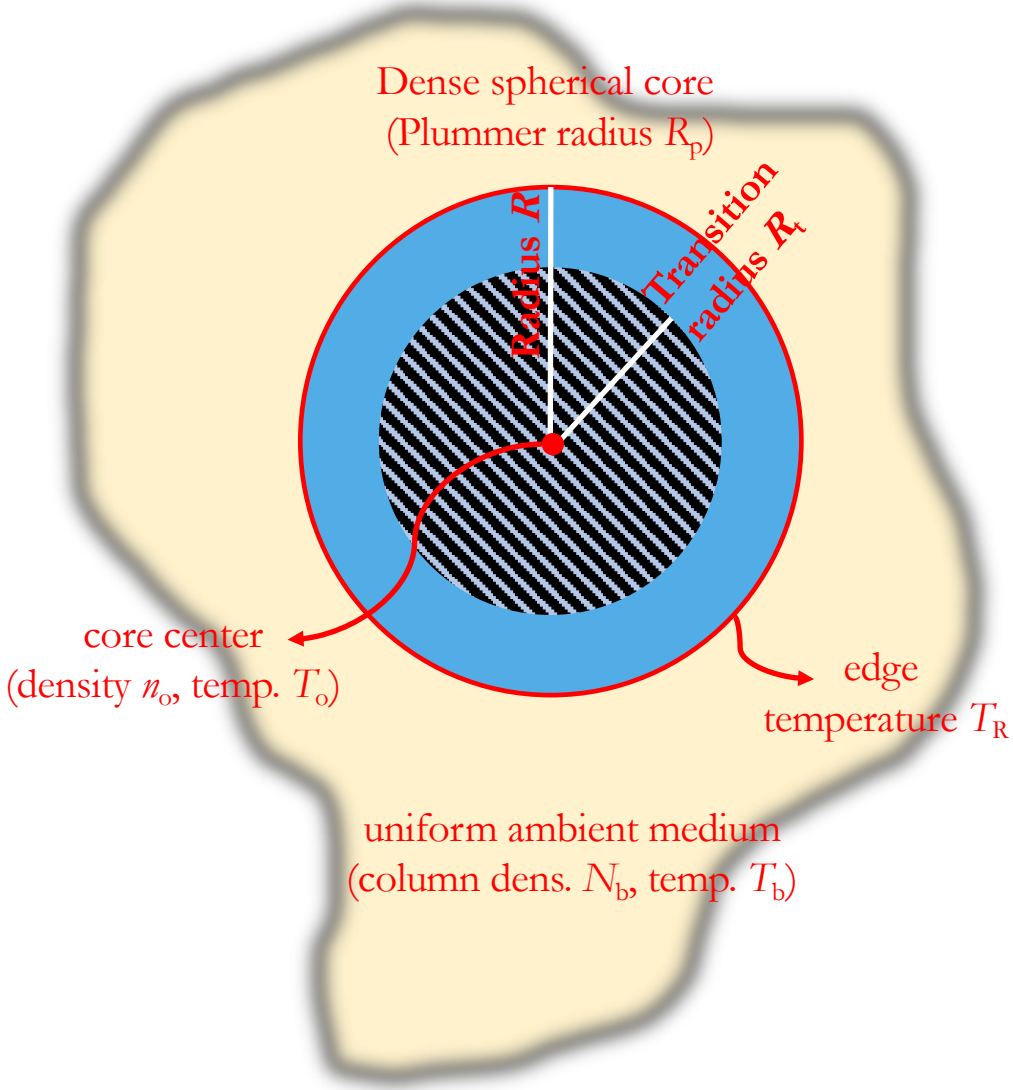
- Systematic dependence of polarization spectrum slope with cloud density

- Hypothesis: differences in grain alignment efficiency
  - outer (warm) grains, well aligned
  - inner (cold) grains, poorly aligned

Far-IR polarization spectrum

Santos et al. (2019, submitted - ApJ, arXiv: 1905.00705)

- Very simple model:
  - Spherical dense core embedded in uniform background
  - Fit 7 model parameters based on *Herschel* data



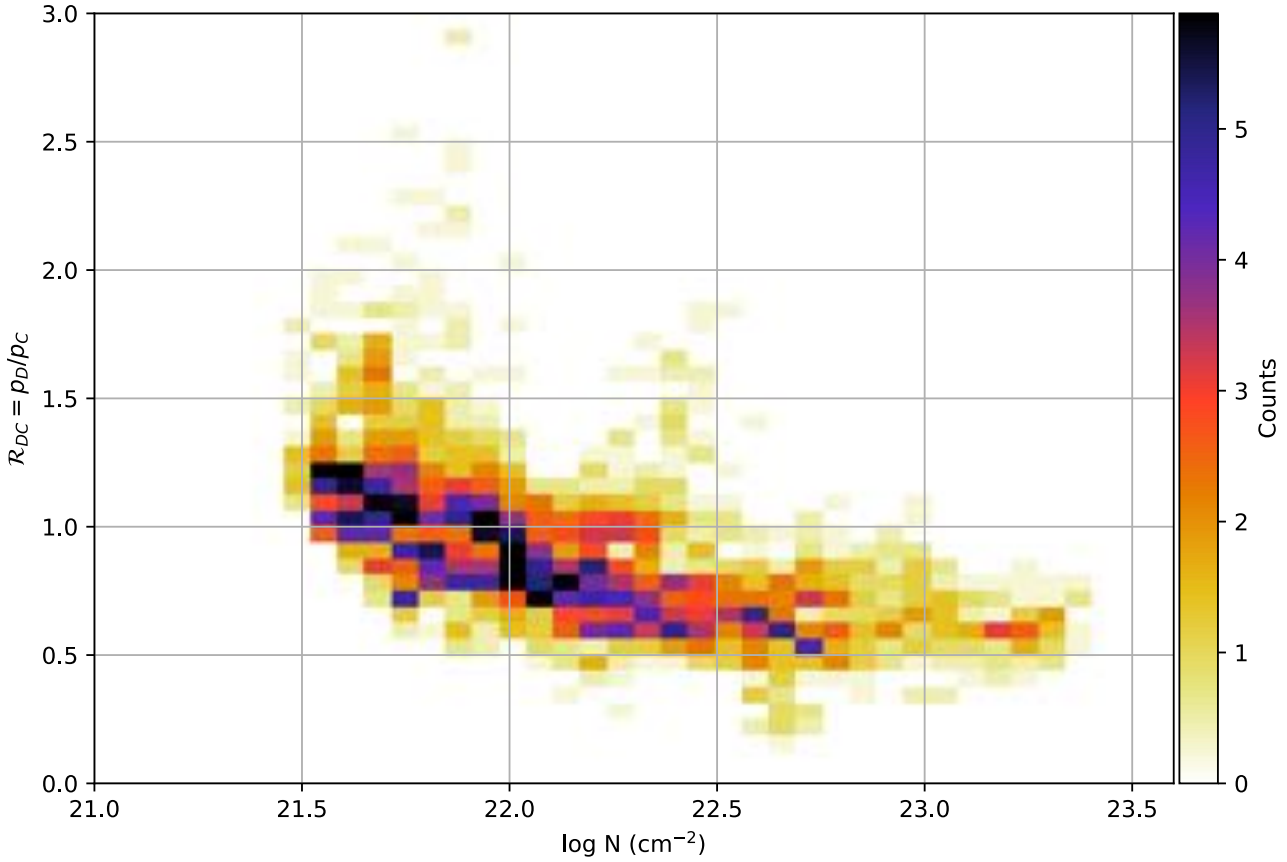
- Transition radius R_T:
  - $r < R_T$: no polarized flux (no grain alignment) – free parameter
  - Test for RATs

Rho Oph A Molecular Cloud

Santos et al. (2019, submitted - ApJ, arXiv: 1905.00705)

- Comparing model with observations:
  - Calculate R_{DC} *vs.* log N for different R_T values: 0.3 *R*, 0.6 *R* and 0.9 *R*

R_{DC} as a function of column density log N

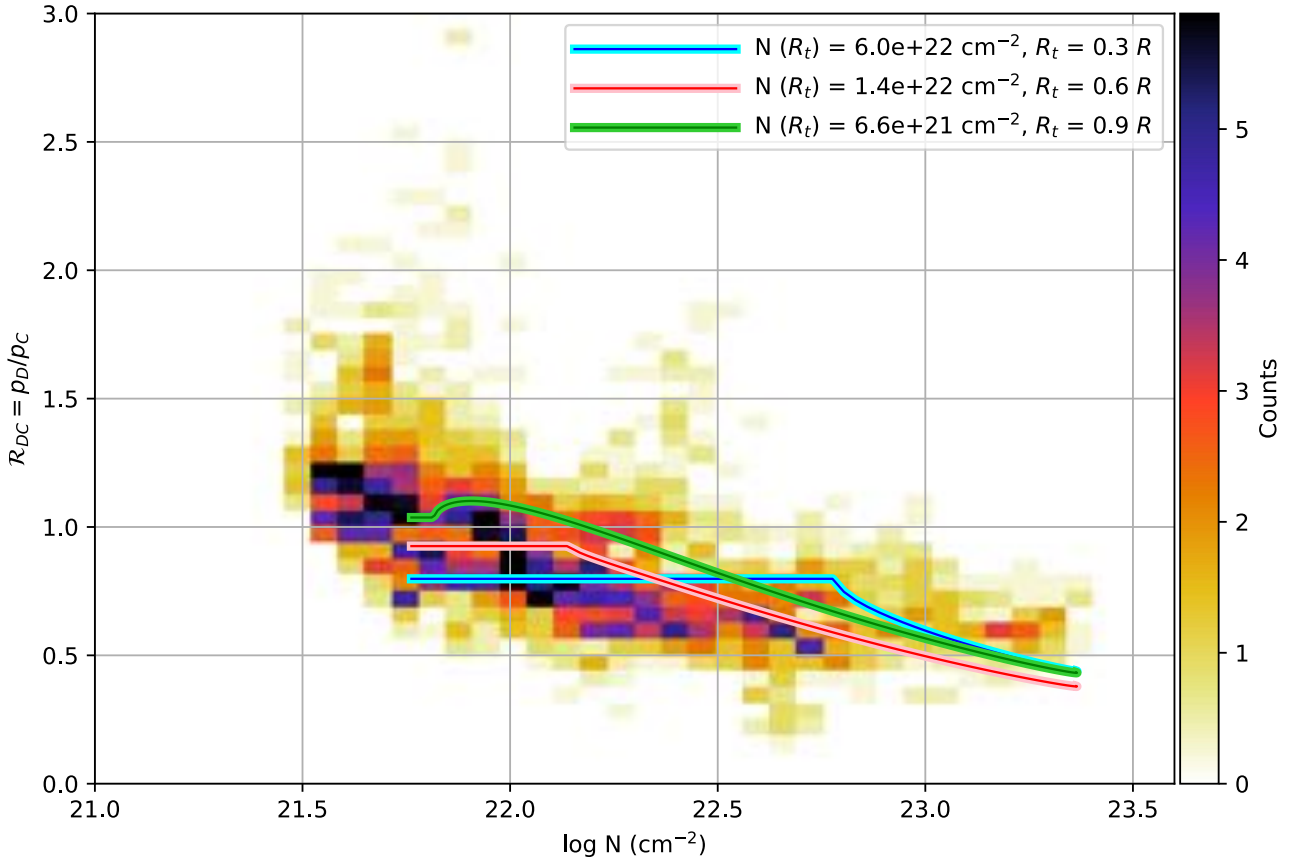


Rho Oph A Molecular Cloud

Santos et al. (2019, submitted - ApJ, arXiv: 1905.00705)

- The observed decrease of ~50% in R_{DC} can be reproduced with the simple model

R_{DC} as a function of column density log N



- Decrease in grain alignment efficiency likely responsible for trends in polarization spectrum slope – support for RATs

Final remarks

- First conclusive observation of systematic variations of the far-infrared polarization spectrum within an interstellar cloud.

- Consistent with reduced grain alignment efficiency in the core, based on very simple modeling of the cloud.

- New method to probe grain alignment efficiency. Grain alignment theory: critical connection between interstellar polarization and magnetic fields – crucial to understand star formation.

Thank you!