Dust polarisation and magnetic field geometry in Proto Planetary Nebulae

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The sample

CRL 618
C-rich
~200 yrs

OH 231.8+4.2
O-rich
~770 yrs
The method

- **Dust continuum emission polarisation mapping**: Principle of alignment of non-spherical spinning dust grains with their long axis perpendicular to the magnetic field.

- **Submillimeter Array in polarimetric mode (interferometry - 8 antennas)**

  Compact configuration: Max. baseline ~70m; 2.5" at 345 GHz

  LSB: ~ 330-334 GHz; USB: ~342-346 GHz
CRL 618

Continuum:
Synthesised beam: 2.2" x 1.9 \(^{\prime\prime}\), PA= -77.6
\(\sigma_I=19.8\) mJy/beam, \(\sigma_Q,U= 2.2\) mJy/beam

Peak intensity: 3.4 Jy/beam
Mean intensity: 1.2 Jy/beam
Linear polarization intensity > 3σ (peak: 4.4σ)
Low P% (<~ 1%)
Mean PA = 96°

- Well defined and organised polar magnetic field.
Continuum:
Synthesised beam: 2.5" x 1.9 ", PA= -77.6
σI=20.5 mJy/beam, σQ,U= 4 mJy/beam
Peak intensity: 0.78 Jy/beam
Mean intensity: 0.31 Jy/beam
OH 231.8+4.2

Four polarised areas. 
Linear polarization intensity > 3σ (peak: 4σ) 
Higher P% with Peak: 15.6 %, Mean: ~4.3% 
X-shaped distribution -> dipole configuration 
Possible toroidal configuration.

► Well defined and organised dipole/poloidal magnetic field.
A magnetic launching mechanism?

- Good alignment of the B-Field vectors with CO outflows in both PPNe.
- Dynamical poloidal field at small scale (close to CS) ➤ outflow launching!?
- Whether the field is dragging and collimating the flow or is dragged is still unclear with the actual data.
Main Findings & Conclusions (I)

- Well organised poloidal magnetic fields are found in CRL 618 and OH 231.8+4.2 (X-shaped)

- P% higher in O-rich than C-rich ► Chemistry dependant (nature and size of the dust grains)

- No detection of molecular line polarisation (Goldreich-Kylafis effect) above 3σ.

- An “evolutionary pattern” of the Bfield configuration is observed ►
Findings & Conclusions (II)

Magnetic distribution vs Evolutionary stage

- PPNe tend to show polar/dipole field configuration while PNe tend to show toroidal configuration (Sabin, Zijlstra & Greaves, 2007)

- Single initial configuration: transition via rotation

- Coexisting configurations: $B_{Pol}$ declines faster ($1/r^2$) than $B_{Tor}$ ($1/r$) (see also Vlemmings, IAU 2010)

![Diagram showing magnetic field configurations and transitions]
Future works

- More detailed polarimetric observations.
- ALMA in polarisation mode: Depth and Speed
- Accurate measurements of magnetic strength.
  - In the CS via spectropolarimetry?
  - Via masers?