Large- and Small-Scale Magnetic Fields in Cygnus-X North

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Planck satellite submm magnetic field vectors over Herschel satellite far-infrared dust emission (at 160µm). Study region shown as red, blue, green, and magenta polygons.
Magnetic Fields: A Friend or Foe of Star Formation?

- Magnetic fields may direct gas flow to high-density regions, helping stars to form.

- Magnetic fields may resist gas flow, hindering star formation.

- Sensing magnetic fields is now fairly easy using near-infrared and/or far-infrared (FIR) polarimetry (SOFIA HAWC+).

- Magnetic field vectors at right are from the Mimir near-infrared (NIR) instrument on the Perkins Telescope in AZ.

*Spitzer* IRAC 8 μm (red), 4.5 μm (green), and 3.6 μm (blue). Vectors show Mimir NIR polarizations. Contours are *Herschel* PACS 160 μm emission.
Lasagna or Spaghetti? Disentangling Cygnus-X Clouds

• Cygnus-X is the closest, richest star-forming region of galaxy-scale significance (e.g., cloud mass \( \gg 10^6 \, M_\odot \), \(~100\) massive stars)

• It has multiple constituent clouds.

• Are the clouds located in distinct layers, like flat noodles in lasagna?

• Or are the clouds composed of filaments that tangle up, like spaghetti?

Herschel 70 \( \mu \text{m (blue)}, 160 \mu \text{m (green)}, 250 \mu \text{m (red)} \)
Credit: ESA/Herschel/SPIRE/PACS/HOBYS
Step 1: Sift through the gas velocity structure

Movie of gas strength, stepping through velocities

Gas quantities, colored by component
Step 2: Identify Zones with a Single Velocity Component

- Radio data can show where only ONE component is present

- Map of where each of the four components dominates over all the others
  - Green = “DR21 Component”
  - Orange = “W75N Component”

- But still no distance information!
Step 3: Use Gaia to help determine Cloud Distances

- Select stars within the one-component sky zones
- Gaia -> stellar distances from parallaxes ($\pi$). Some stars in foreground, some in background.
- Multi-wavelength photometry -> find jumps in stellar color ($HM_0 \rightarrow HM_1$)
- Near-infrared polarimetry -> find jumps in magnetic field properties ($U_0, Q_0 \rightarrow U_1, Q_1$)

Here, stars in the “DR21 Component” – sliced into 6 smaller zones
Findings – Lasagna Wins!

• Find distinct, well-separated distances to the clouds and zones (-> the lasagna model)

• Clouds likely not colliding to trigger stars to form

• Can proceed to interpret SOFIA polarization maps for magnetic field properties of **single** cloud

• Can also proceed to full interpretation of the NIR polarization map across the larger field

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