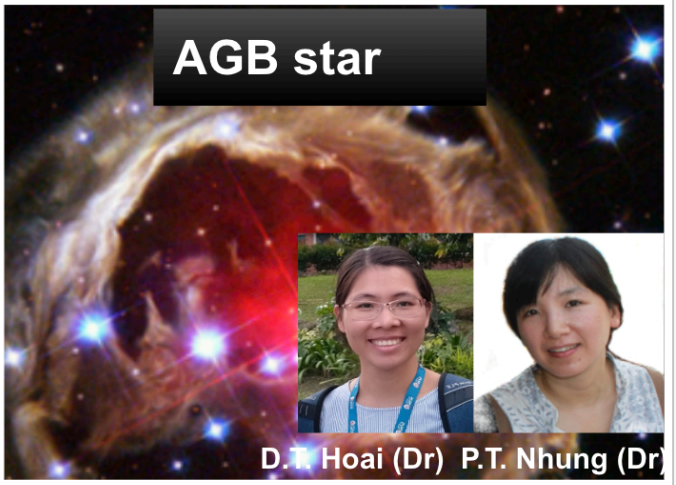
Studying Magnetic Fields using Dust Polarization

Nguyen Bich Ngoc, Vietnam National Space Center

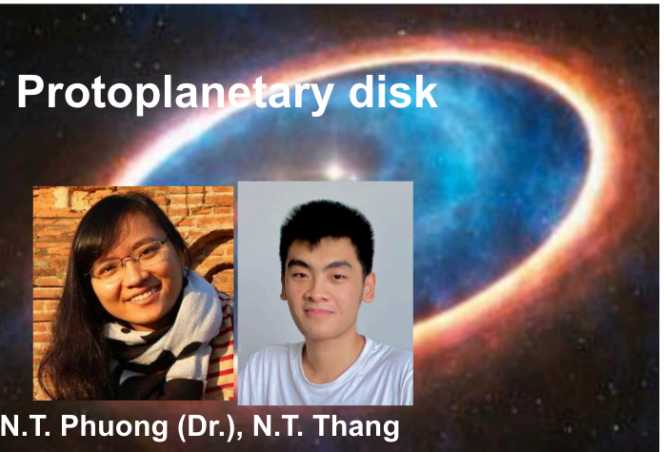
TNU, Buon Ma Thuot, 2024

Scan me!

https://dap.vnsc.org.vn/

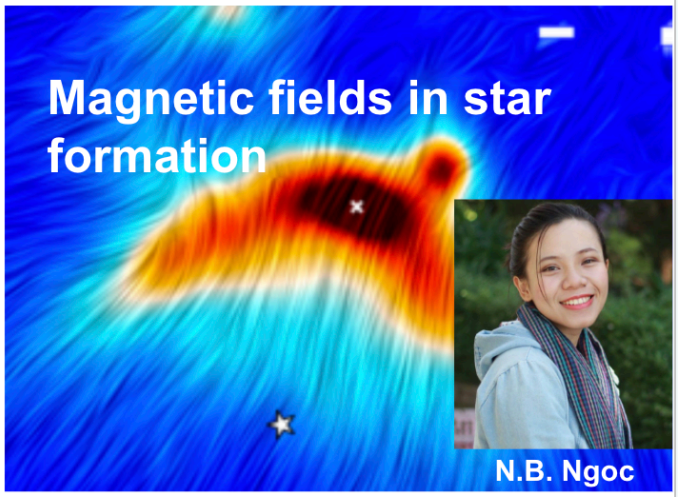


Department of AstroPhysics (DAP/VNSC, Hanoi)



P.N. Diep
Dr., Department Head

Pierre Darriulat
Pr, Scientific Adviser



Studying Astrophysics in Vietnam

Where you can study bachelor/master/PhD

USTH
VIETNAM FRANCE UNIVERSITY

University of Science and Technology of Hanoi

Only one university offers astrophysics training in Vietnam at the bachelor's and master's levels (major: space science)

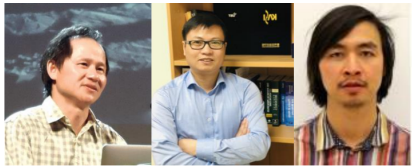
Where you can apply for an internship

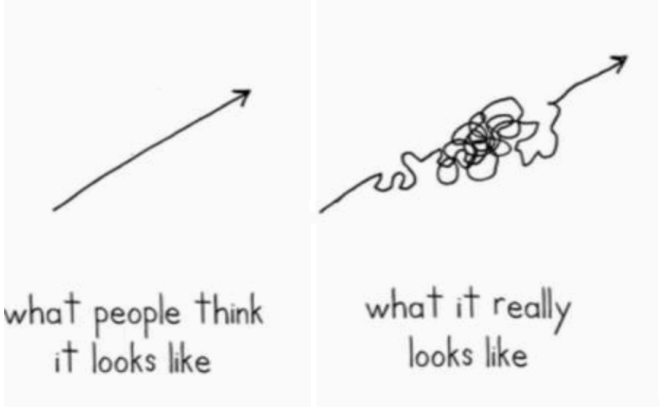
- **Our department at VNSC**
- **VARNet**: Vietnam Astrophysics Research Network

Since 2020
Aim: train young researchers

- **SAGI:** Simons Astrophysics Group, since 2022

Aim: to facilitate astrophysics research collaboration between domestic and international researchers





About me

My home town: here! Buon Ma Thuot City

Bachelor: Pedagogical Physics, Tay Nguyen University

3-year teaching to save money for studying higher

Master: Space Science, USTH (Vietnamese-France University).
Internship: Mercury surface (Paris Observatory)

PhD: co-supervision Vietnam (VNSC) + Korea (KASI)
Topic: Magnetic fields and Dust in Star Fomation

ASTROPHYSICIST

what people think I do

what friends think I do

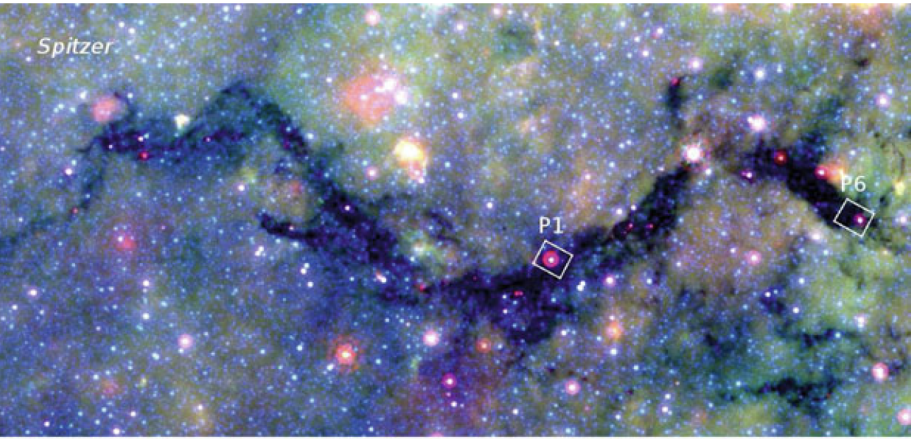
what Mom thinks I do

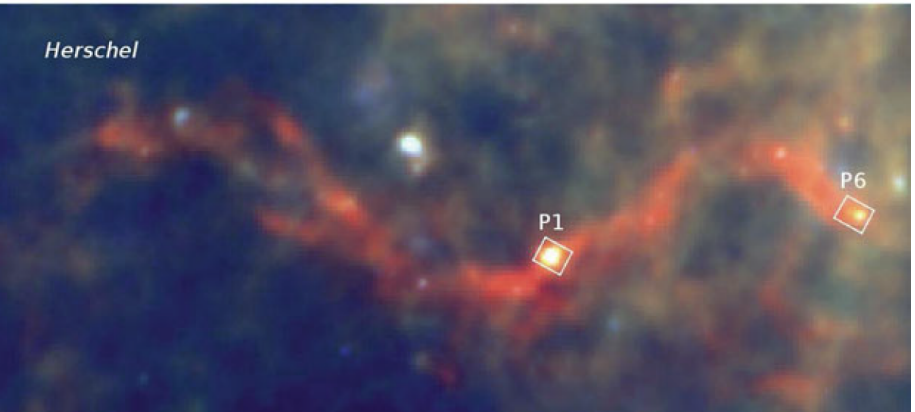
what I think I do

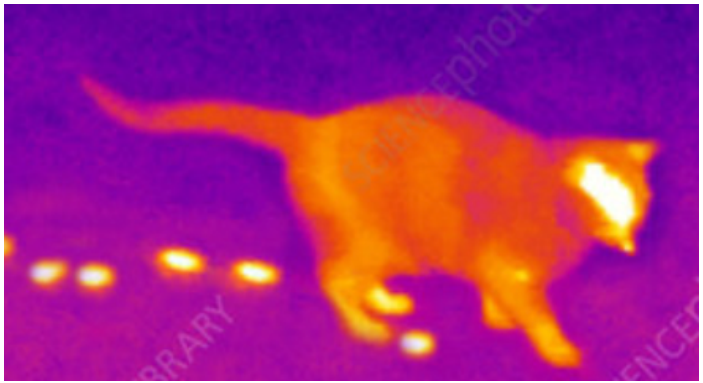
Molecular clouds

dense and are cold (10K - 100K)

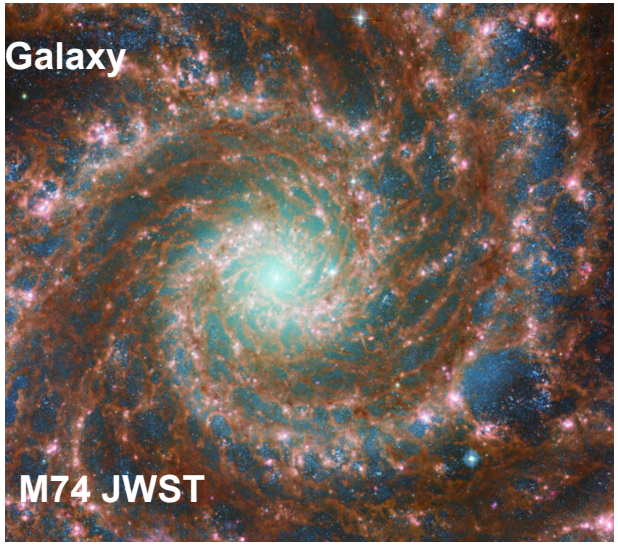
Giant molecular clouds can contain as much as 10^4 solar masses of gas



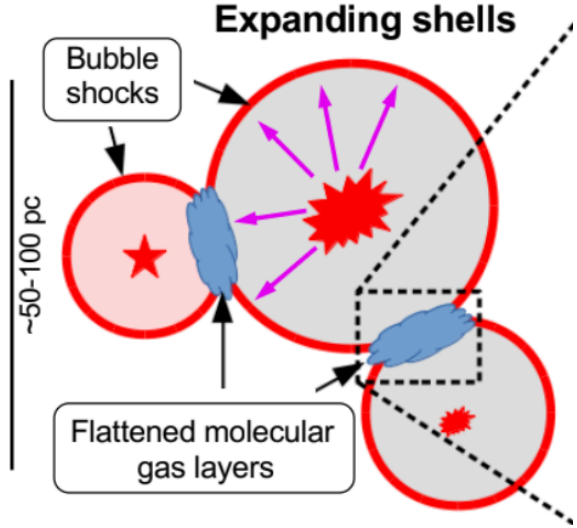


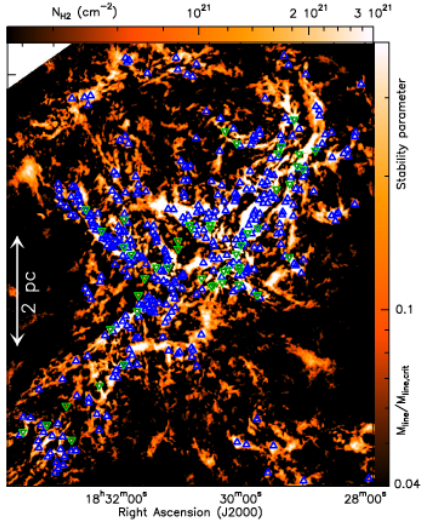


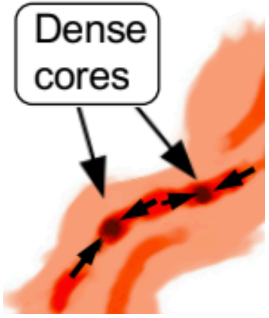
Star Formation

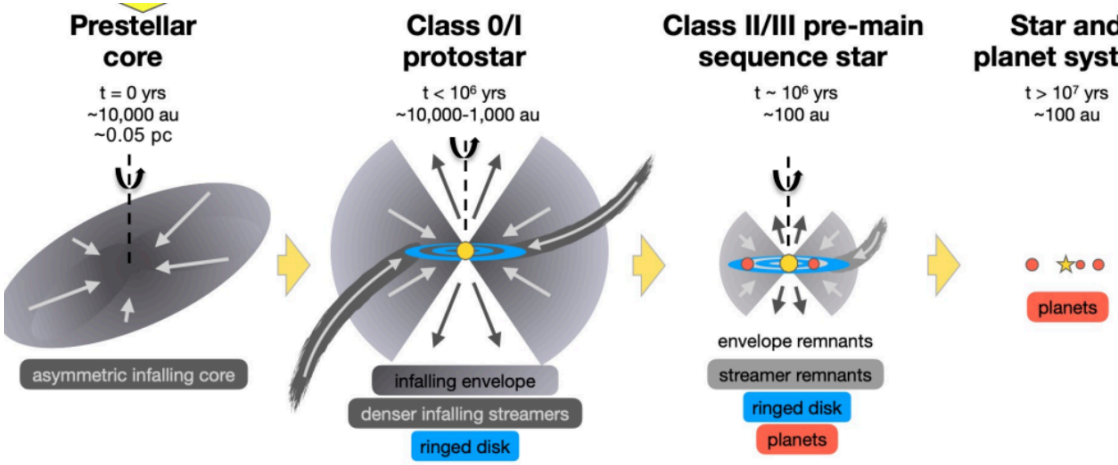


100kpc

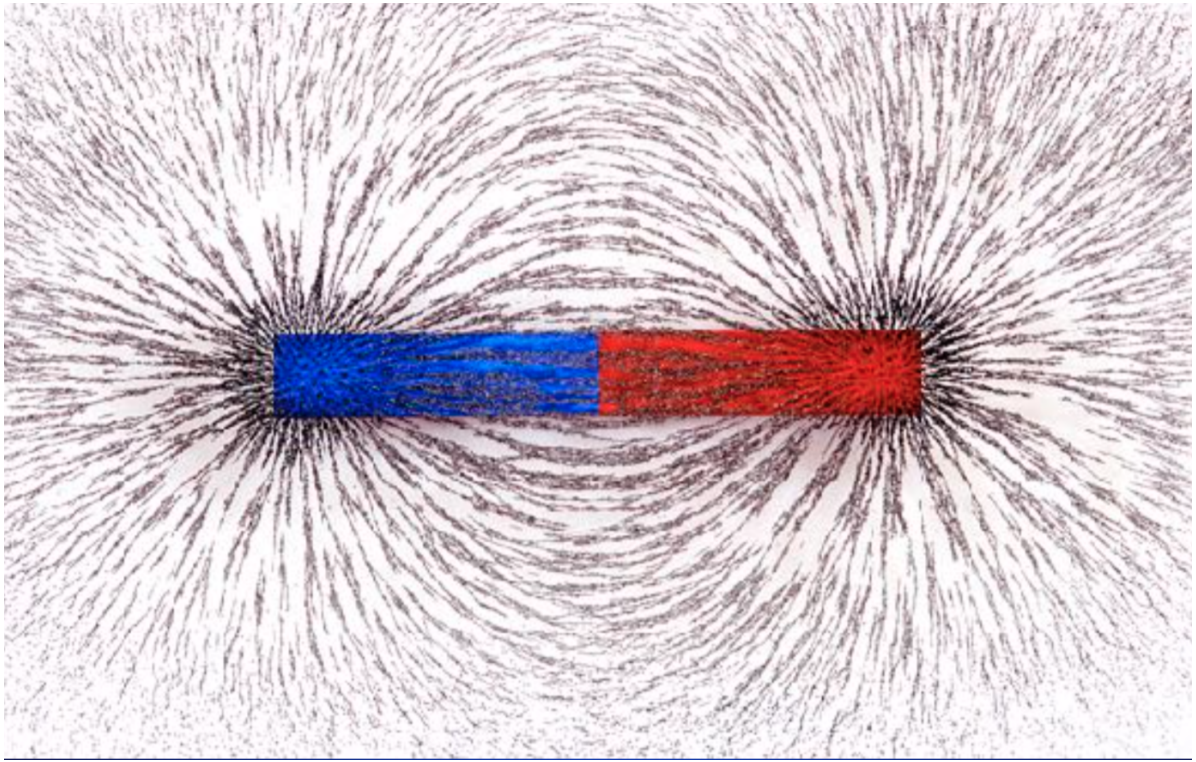




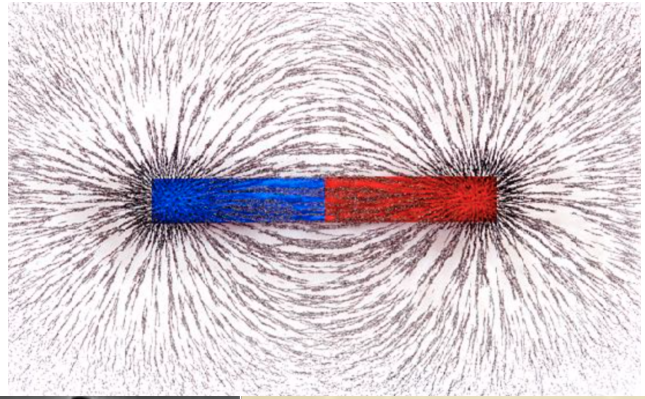


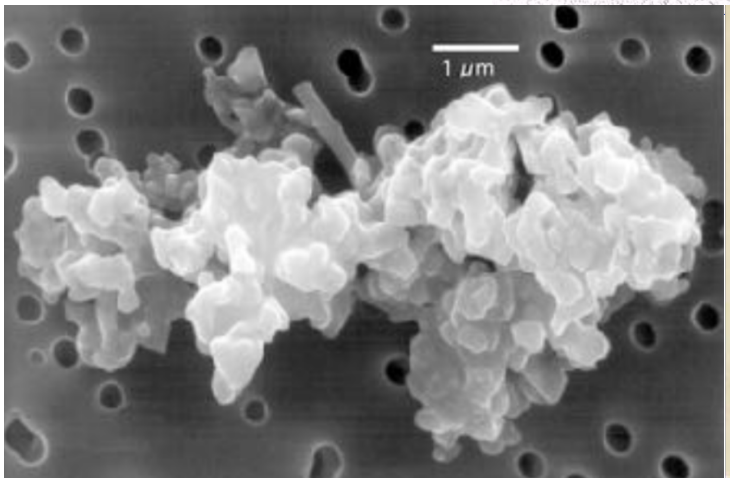


Magnetic fields are invisible



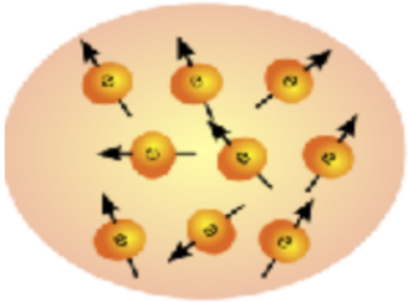
Magnetic fields are invisible. We need tracers.

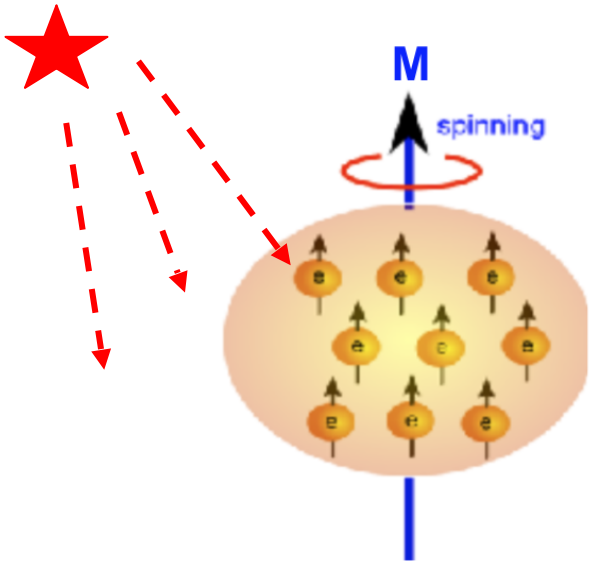




How Dust Grains Aligned in B-field?

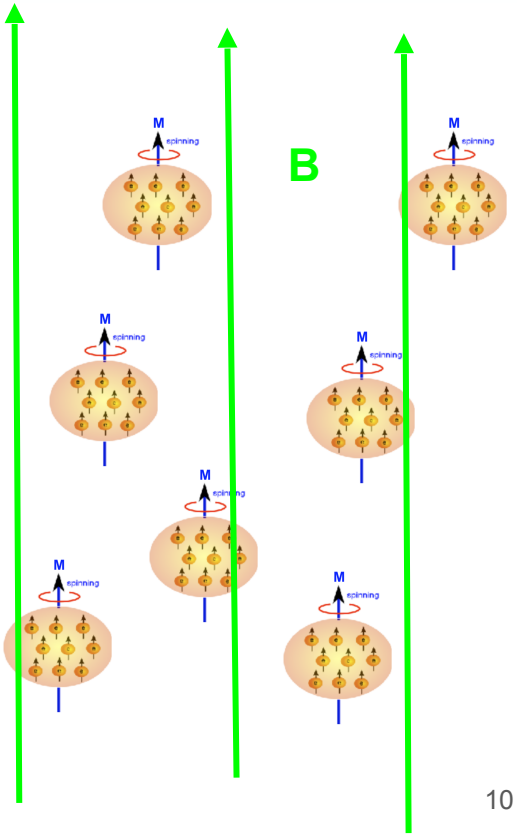
Stationary
M = 0





RAdiative Toque (RAT)

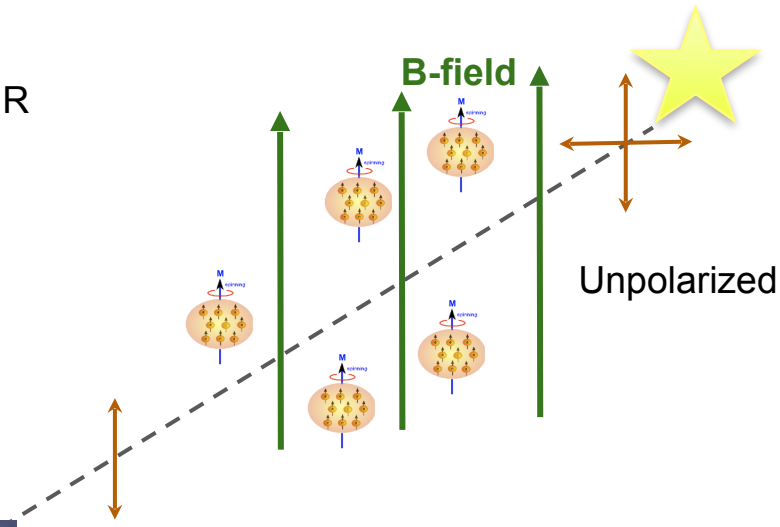
E.g. Lazarian, Hoang 2007



Dust alignment

Stellar emission

Optical/NIR

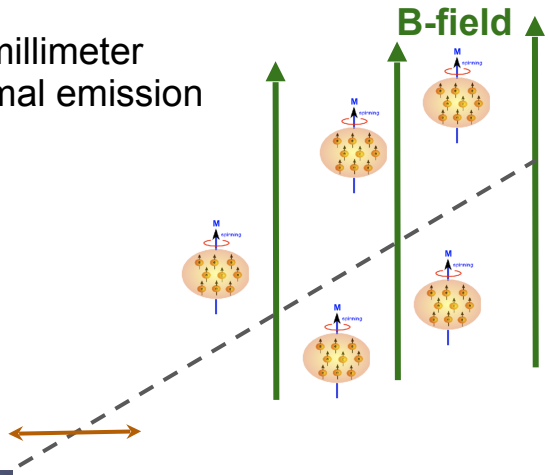


Polarization // B-fields

Our study

Dust thermal emission

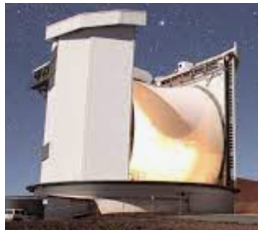
FIR/Sub-millimeter
Dust thermal emission

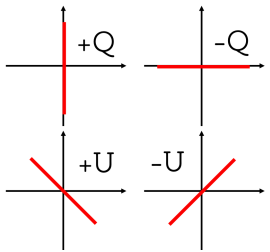


Polarization ⊥ B-fields

Study B-fields using polarization data

Girart + 2006





I Q U

Polarization angle (PA) is defined by $\mathrm{PA} = \frac{90}{\pi} \arctan(U/Q)$ (degree)

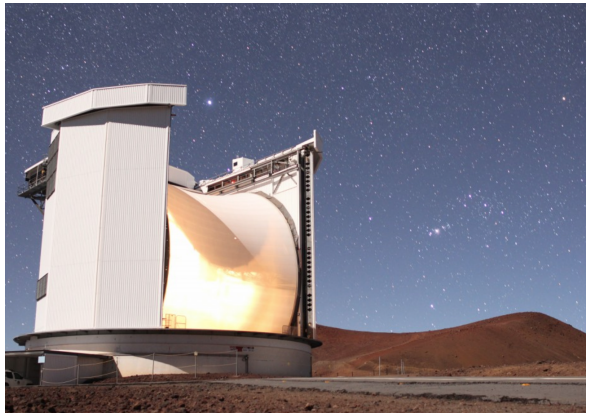
Polarized intensity (PI) is defined by $\mathrm{PI} = \sqrt{Q^2 + U^2}$

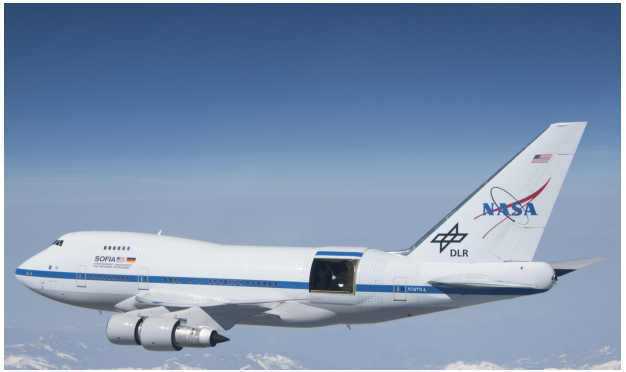
Polarization fraction (p) is defined by $p = 100 \times \frac{PI}{I} = 100 \times \frac{\sqrt{Q^2+U^2}}{I}$ (%)

Rotate the pol. vectors by 90° —> B-field vectors

- Widely used to probe B-fields in various scales
- B-field morphology
- B-strength could be estimated by DCF method (Davis 1951; Chandrasekhar-Fermi 1953)

Telescopes





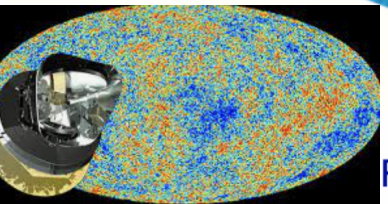
JCMT - POL2

is the largest sub-mm single-dish telescope (15 m diameter), located in Hawaii

SOFIA - HAWC+

is a Boeing 747SP with 2.7-m telescope

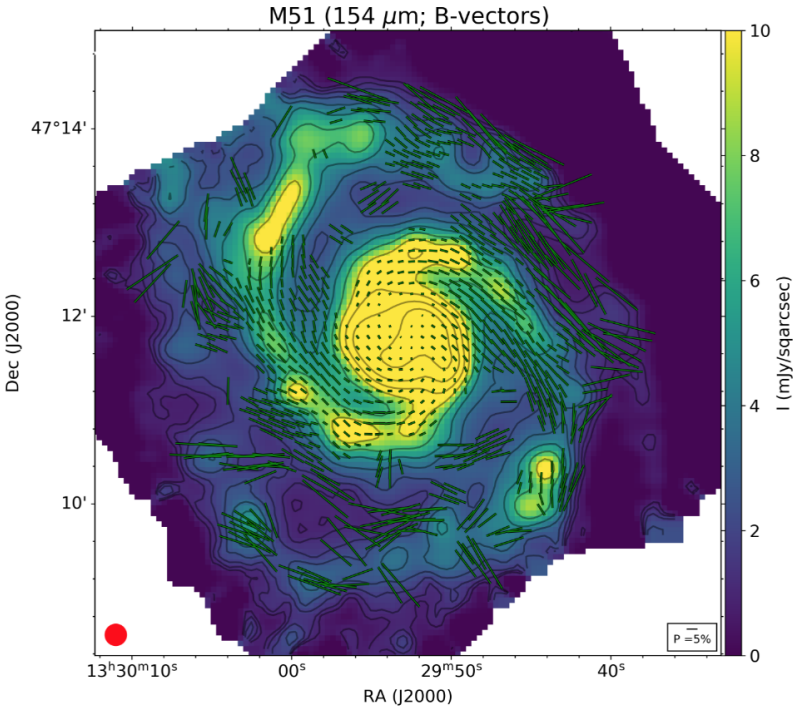
	Unit	HAWC+ Band A	HAWC+ Band B	HAWC+ Band C	HAWC+ Band D	HAWC+ Band E	JCMT	JCMT
Mean wavelegnth		53	63	89	154	214	450	850
Beam size (Resolution)	arcsec	4.9	10.5	7.8	13.6	18.2	9	14



Rs

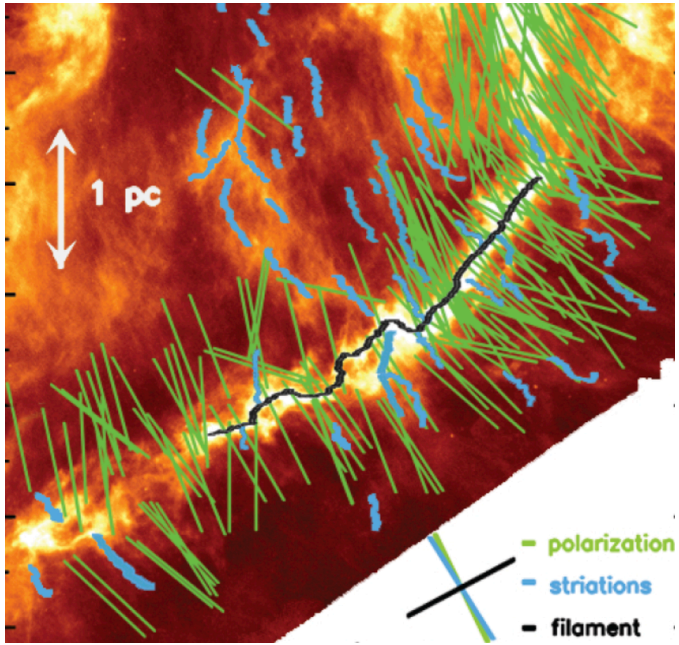
Planck Collaboration

Galaxy: M51

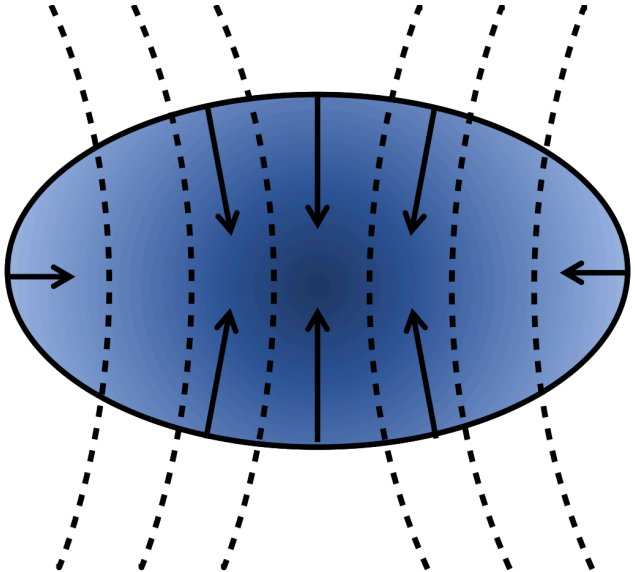


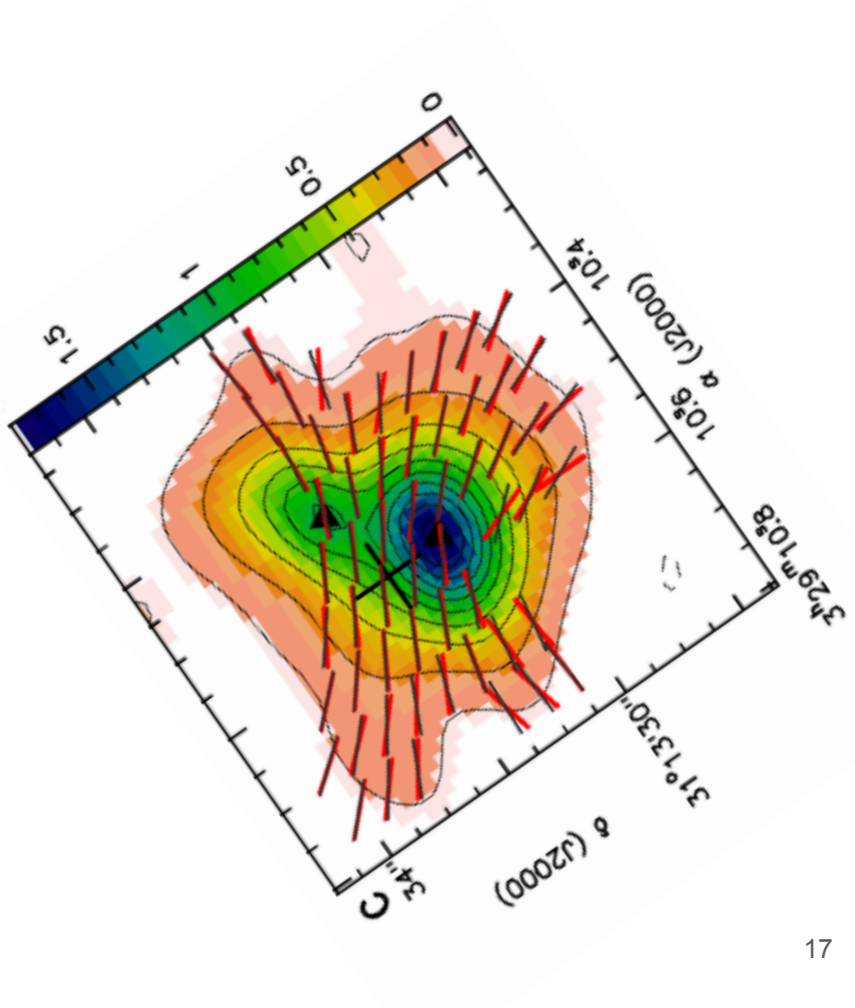
SOFIA/HAWC+ data

Molecular cloud: Filament



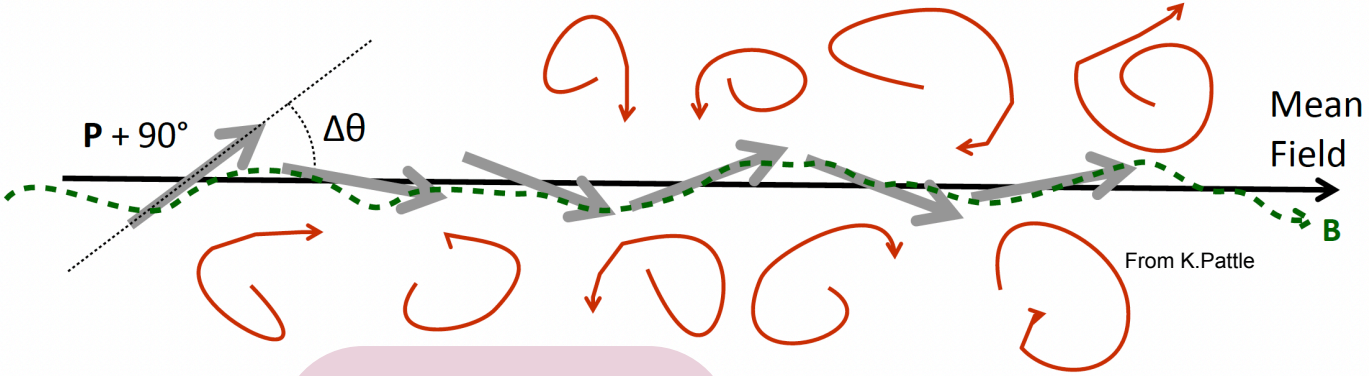
Core





Magnetic field strength: Davis, Chandrasekhar & Fermi method

It is based on the assumption that **gas turbulent motion is the driving of B-field distortion**



$$B_{\mathrm{POS}} = 9.3\sqrt{n(\mathrm{H}_2)}\frac{\Delta V}{\sigma_\theta}$$

(cf. Crutcher et al. 2004)

$n(\mathrm{H}_2)$: volume density [cm-3]

ΔV: FWHM non-thermal gas velocity dispersion [km/s]

σ_θ: polarization angle dispersion [deg]

B_{POS}: Mangetic field strength in plane of the sky [μG]

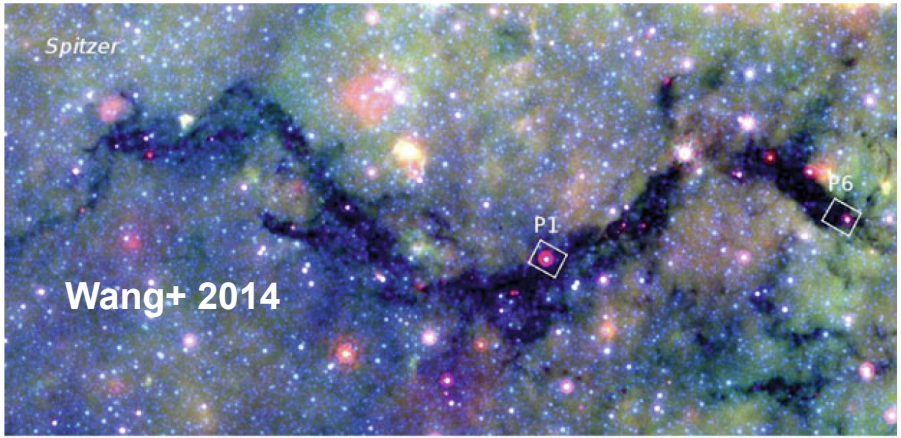
Hands on

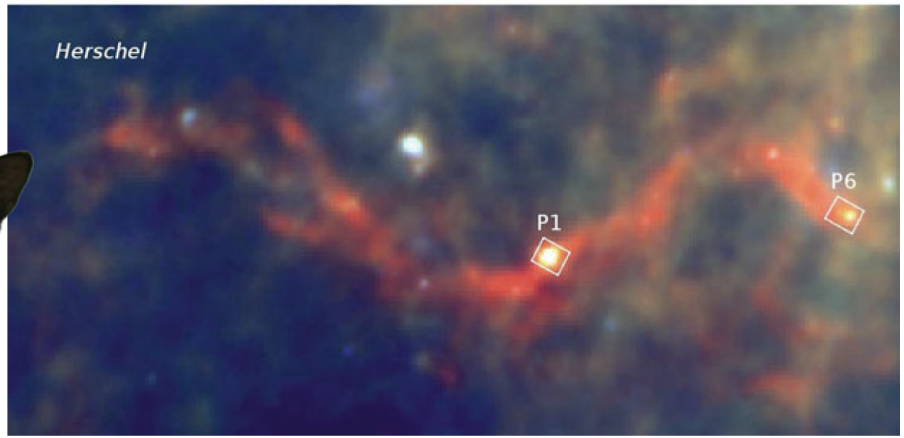
Using polarization data to 1/ plot map of B-field (B-field orientation)
2/ calculate B-field strength

Our target: IFDC G11.11 -0.12 (Snake filament)

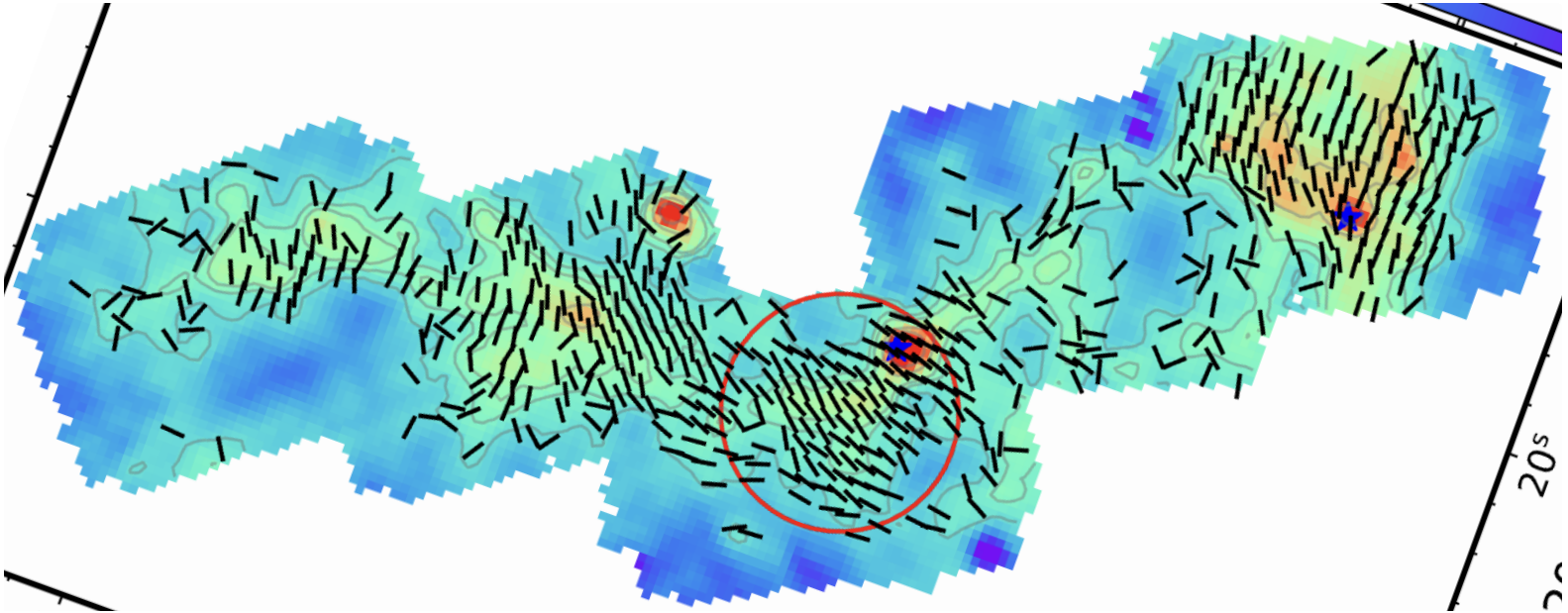
G11 is a filament in the galactic plane
Distance: 3.6 kpc from the Earth
Length: 30 pc
Mass: 10^4 $M_\odot$

In early phase of star formation with 18 cores along the filament and two high-mass protostar candidates (P1, P6) (Henning+2010)





SOFIA/HAWC+ data, 214 um


20s

ASTROPHYSICIST

what people think I do

what friends think I do

what Mom thinks I do

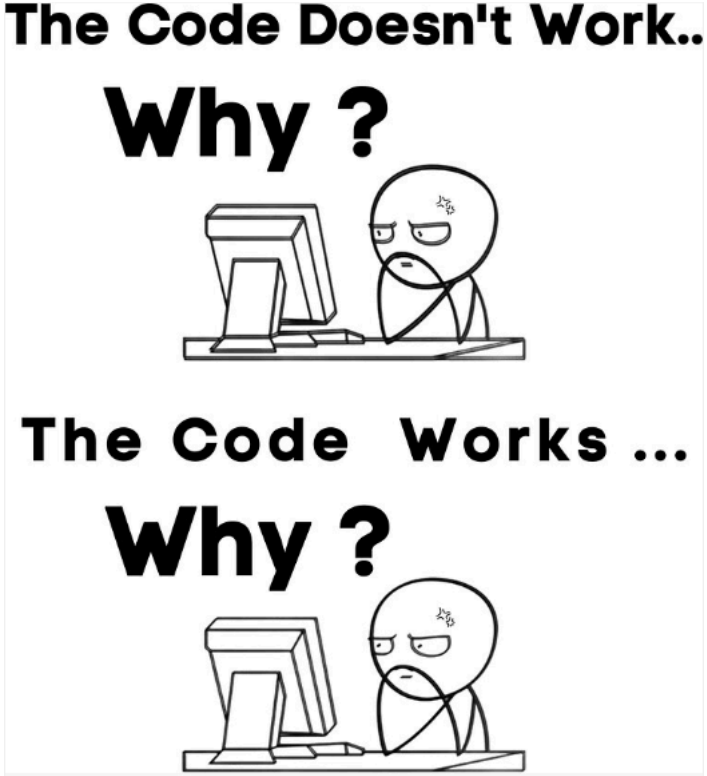
what I think I do

```
#mask noise
# Create a mask where the signal-to-noise ratio of I is less than 200
mask1 = np.where(I.data/sigma_I.data < 200)
def apply_mask(input_map):
    input_map[mask1] = np.nan # Set the values in the input map corresponding to the mask to NaN
    return input_map

I.data = apply_mask(I.data) # Apply the mask to the I data

# Create a figure using aplpy after applying the mask
fig = aplpy.FITSFigure(I,hdu=0)
fig.show_contour(I,levels=[0.5,0.8,1.3,1.5],colors=['lightseagreen','steelblue','slateblue','darkblu
fig.show_colorscale(cmap='YlOrBr',vmin=0.1, vmax=10,stretch='log')
fig.add_colorbar()
```

what I really do


The Code Doesn't Work..
Why ?
The Code Works ...
Why ?