SOFIA/HAWC+ POLARIZATION IN GALAXIES: IT'S ALL ABOUT THE MAGNETIC FIELDS

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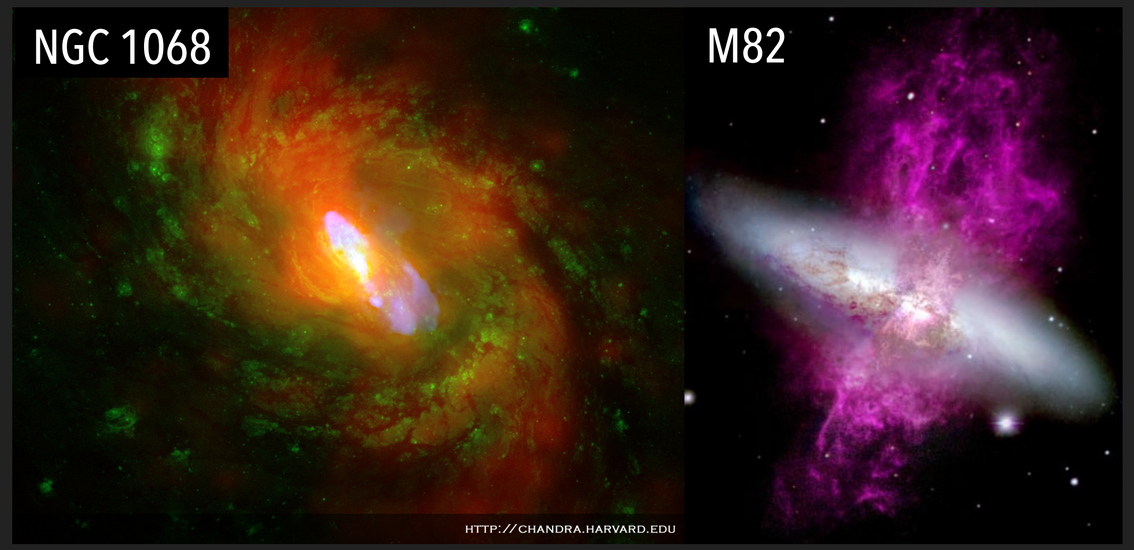
Lopez-Rodriguez et al. (in preparation)

ROLE OF GALACTIC MAGNETIC FIELDS IN GALAXIES

Magnetic fields play important roles in:

- dynamical evolution of the interstellar medium of galaxies,
- processes governing formation of stars, and
- dynamical evolution of galaxies.

What is the geometry of these large-scale magnetic fields?
What are the dominant physical mechanisms of these large-scale magnetic fields?

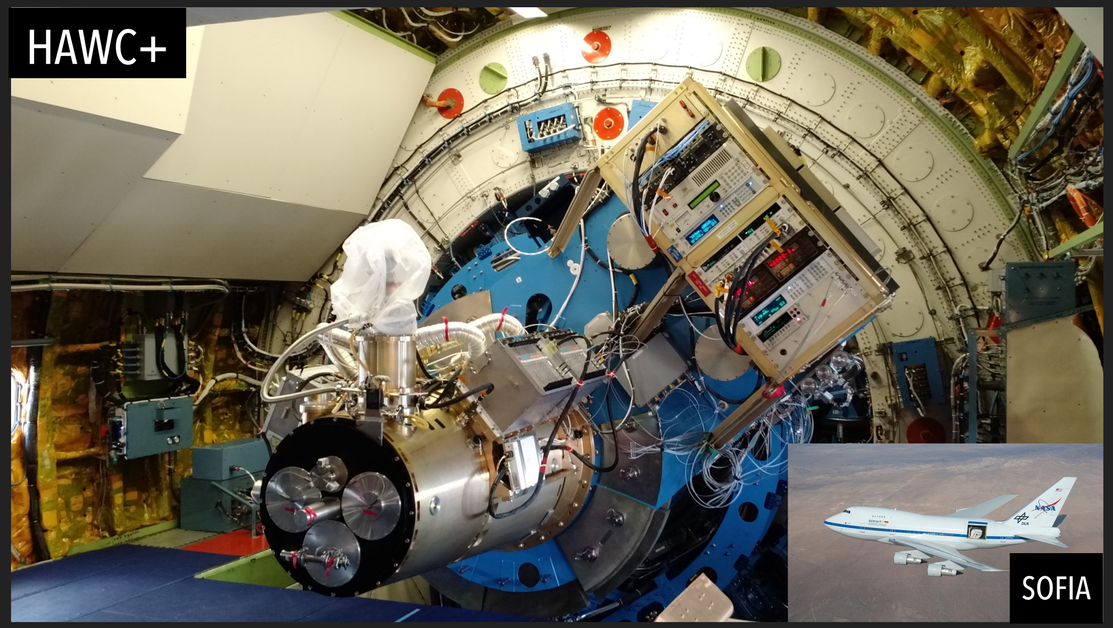


M82, imaged by the WIYN telescope in Halpha (magenta) and HST in BVI continuum colors (Smith, Gallagher, & Westmoquette). Several of the largest scale filaments trace all the way back to super-starclusters embedded in the disk (link). NGC 1068 imaged by Herschel (infrared) and Chandra (X-rays).

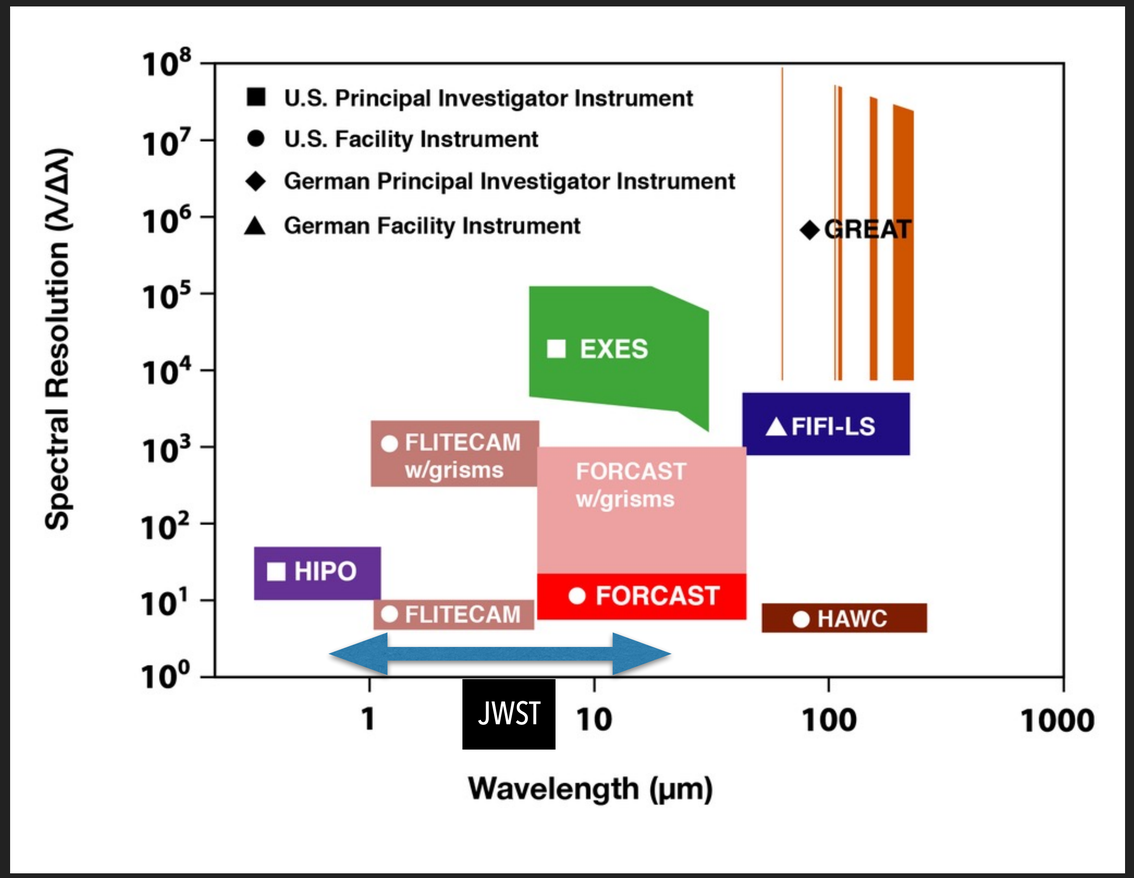
However magnetic fields are notoriously difficult to observe.

HAWC+ POLARIMETRIC OBSERVATIONS WITH SOFIA

The HAWC+ instrument on SOFIA provides a new tool for studying magnetic fields in galaxies.



HAWC+ observed the far-infrared emission of dust grains, and samples different dust temperatures in the range of 10K to 100K.

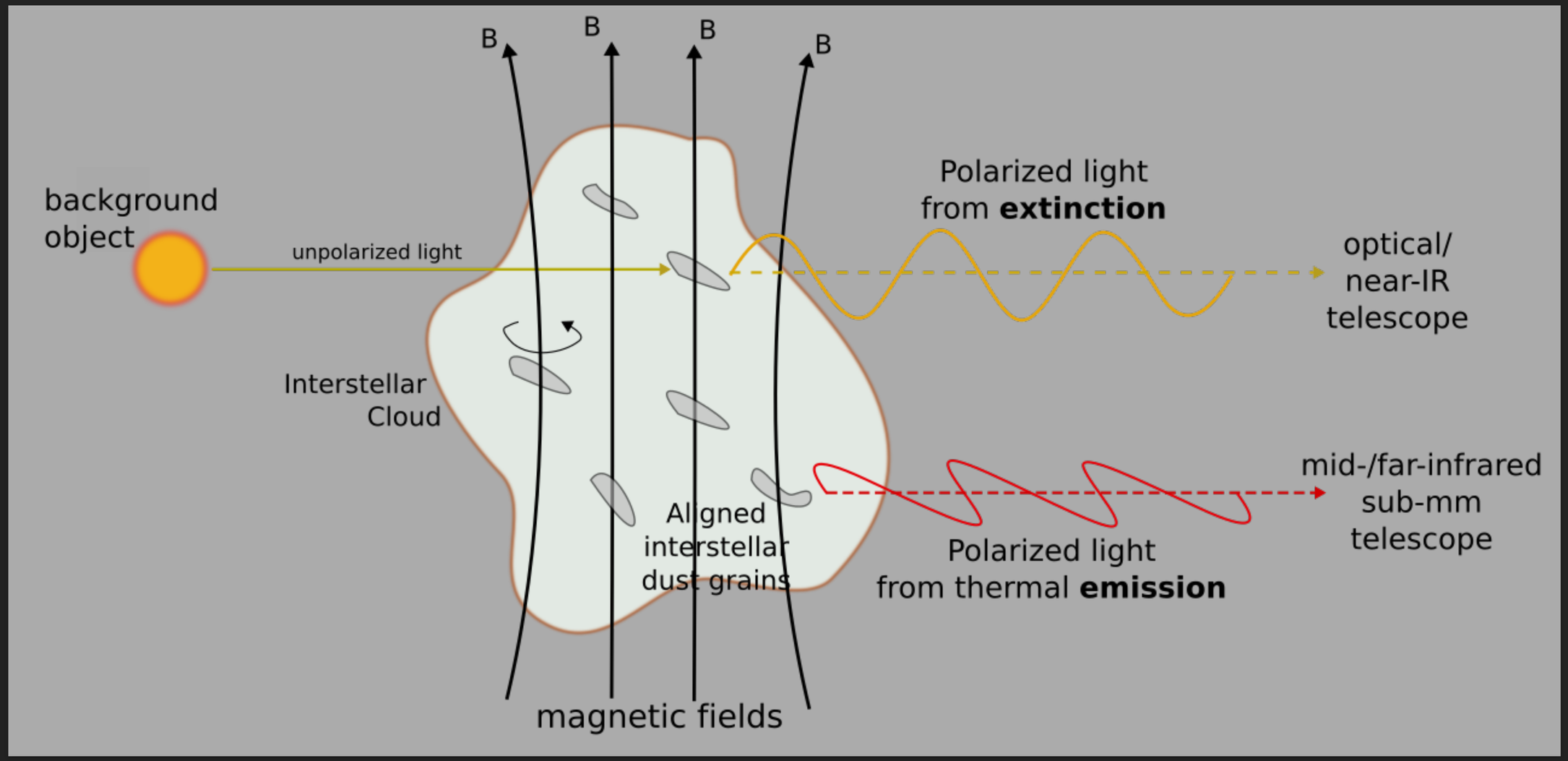


The angular resolution and sensitivity of HAWC+/SOFIA can study polarized emission in external galaxies.

UNDERSTANDING POLARIZATION ARISING FROM DUST

Polarimetry is the measurement of the direction of vibration of electromagnetic waves.

Magnetic field can induce a preferential orientation of dust grains



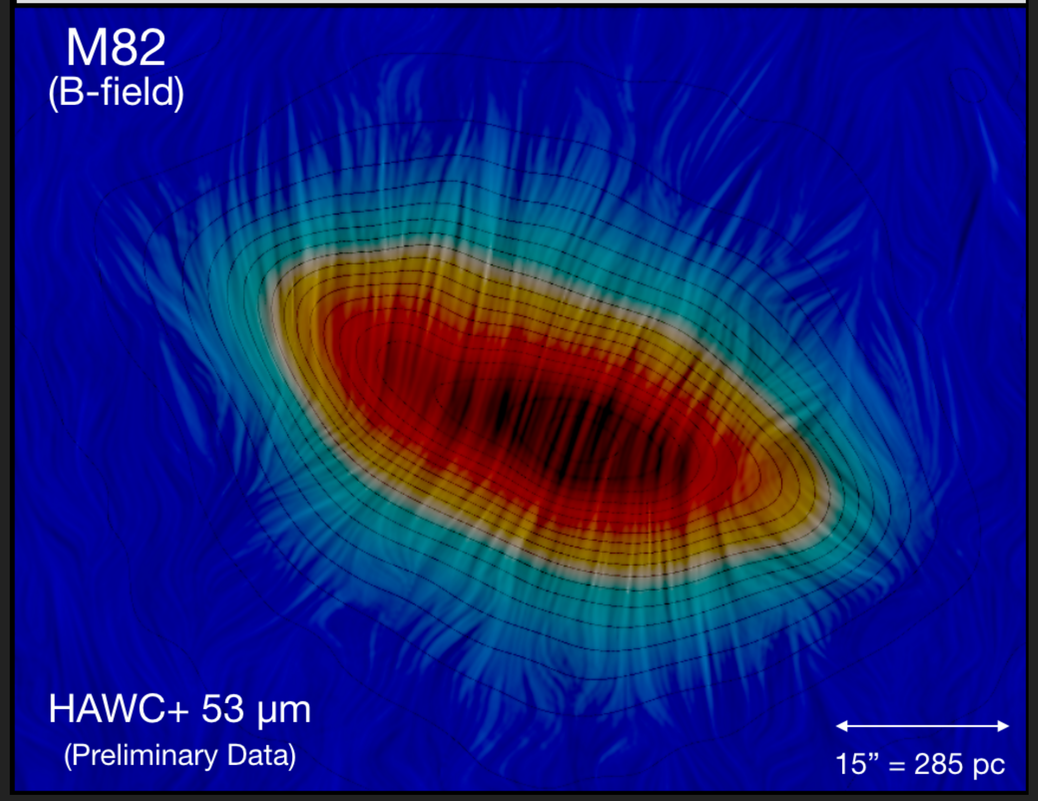
FIRST DETECTIONS OF POLARIZED FAR-INFRARED EMISSION FROM EXTERNAL GALAXIES

STARBURST GALAXY

What are we learning here?

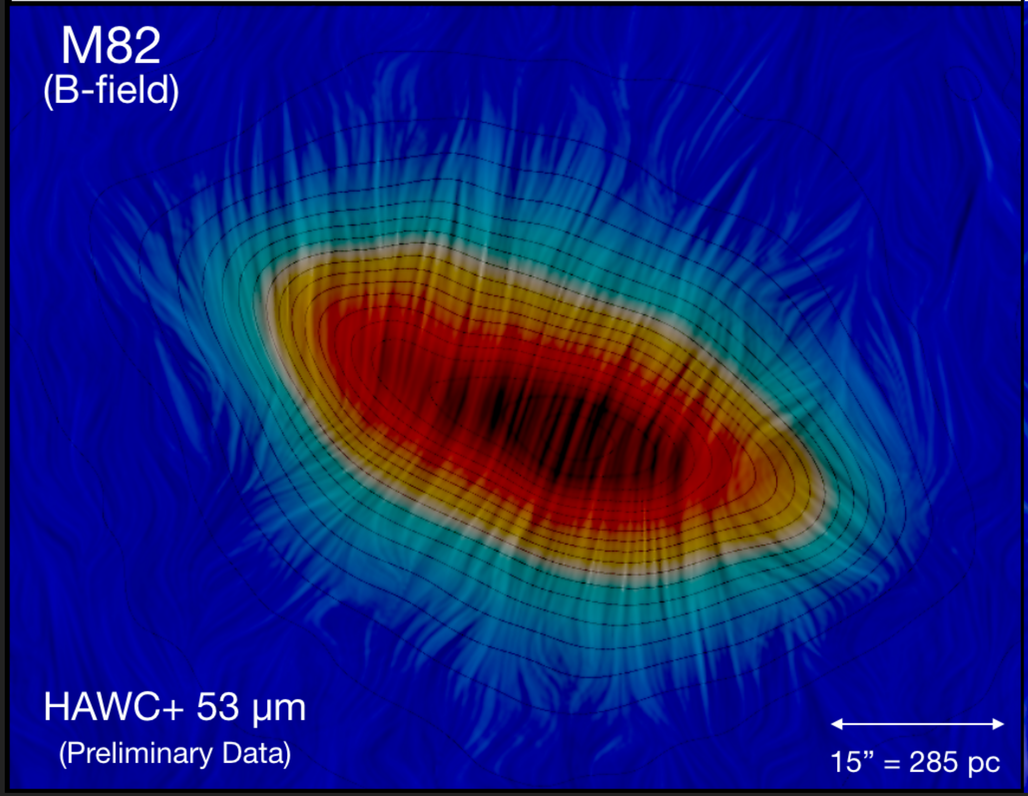
Galactic dusty outflows are polarized due to magnetically aligned dust grains

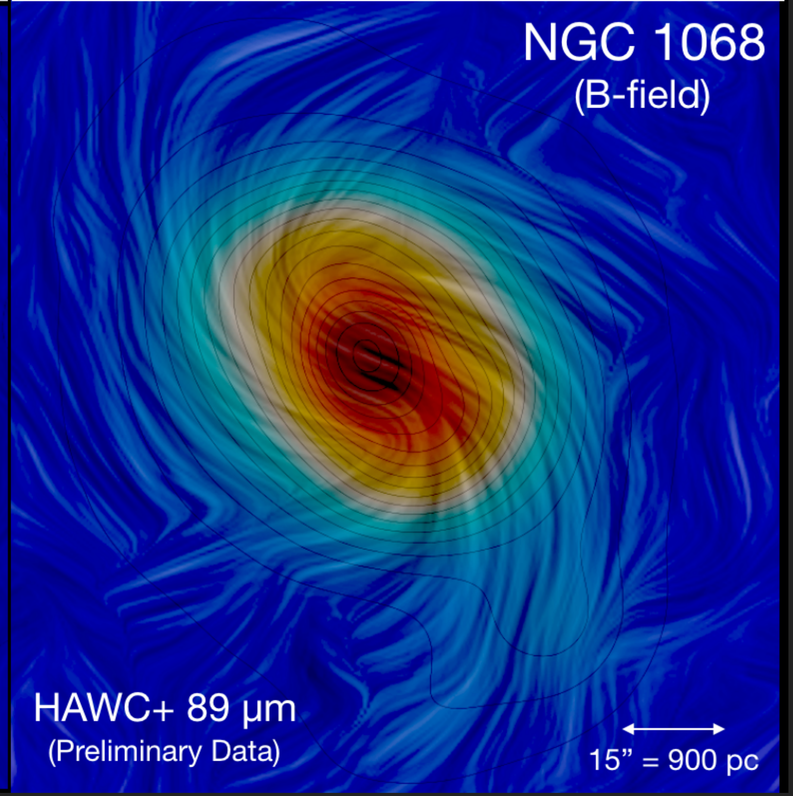
Polar magnetic fields



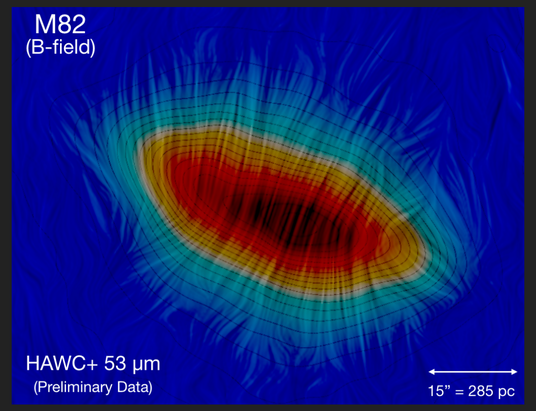
FIRST DETECTIONS OF POLARIZED FAR-INFRARED EMISSION FROM EXTERNAL GALAXIES

STARBURST GALAXY	MASSIVE SPIRAL GALAXY
What are we learning here?	
Galactic dusty outflows are polarized due to magnetically aligned dust grains	Magnetic arms due to polarized emission from aligned dust grains
Polar magnetic fields	Spiral magnetic fields

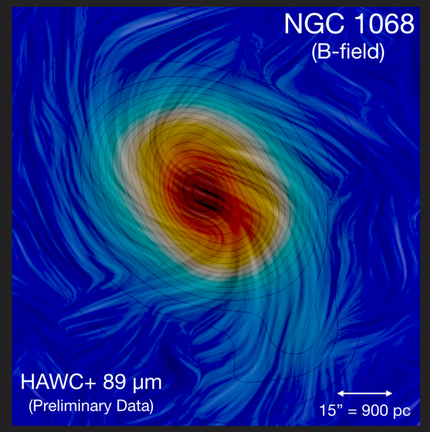




SUMMARY



Distance = 13 million light-yr
Large-scale B-field range = 7,400 light-yr



Distance = 41 million light-yr
Large-scale B-field range = 24,000 light-yr

- **What we did:**
  - Far-infrared polarimetric observations of external galaxies with HAWC+.
- **What we found:**
  - Large-scale magnetic fields in starburst and massive spiral galaxies.
  - Polarized emission from magnetically aligned dust grains at large scales.
- **What we learnt:**
  - **M82:** The starburst is sufficiently high compared to the potential energy of the gravitational field to expel large amounts of gas and dust from the galaxy, and the B-fields threading the interstellar medium are drawn out with it.
  - **NGC 1068:** Forces exerted by the B-field are dominated by disk rotation.

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