



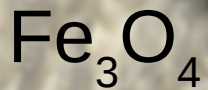
Ye olde magnetism



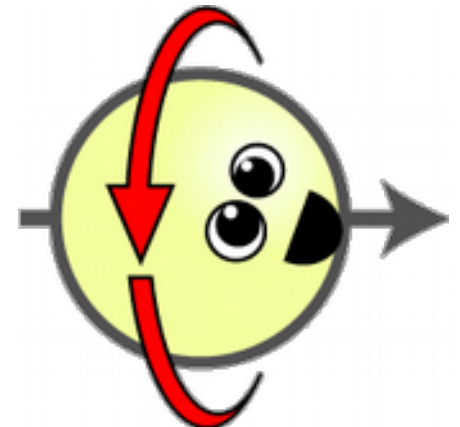
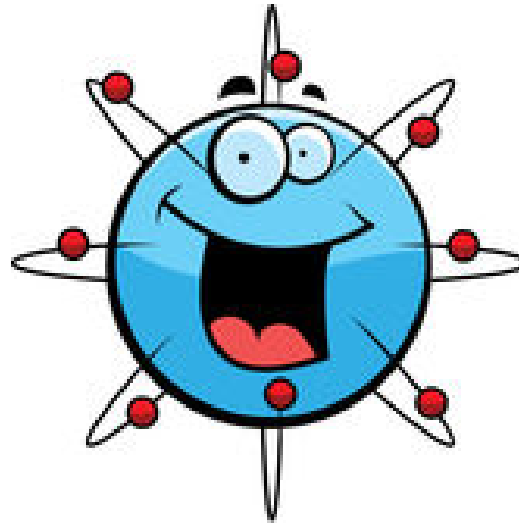


Ye olde magnetism

Magnetite : Lodestone

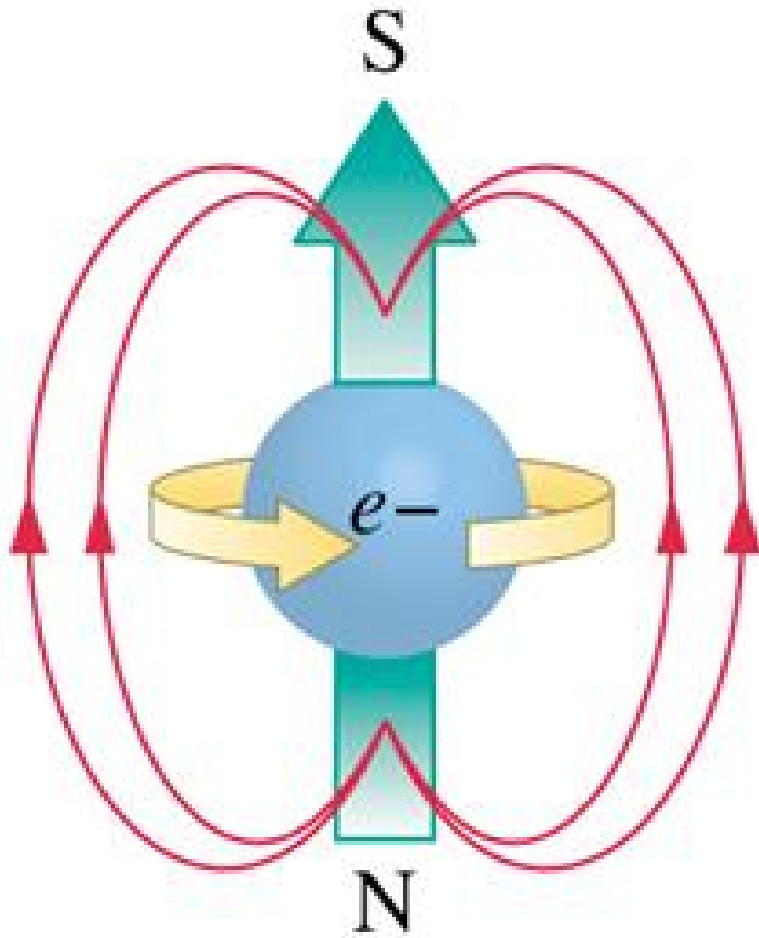


- 2500 BC: Foggy Chinese general
- 2000 BC: Greek shepherd stuck
- 1000 BC: Viking explorers
- 1500 AD: Earth's magnetic field
- 1800 AD: Maxwell links electricity & magnetism

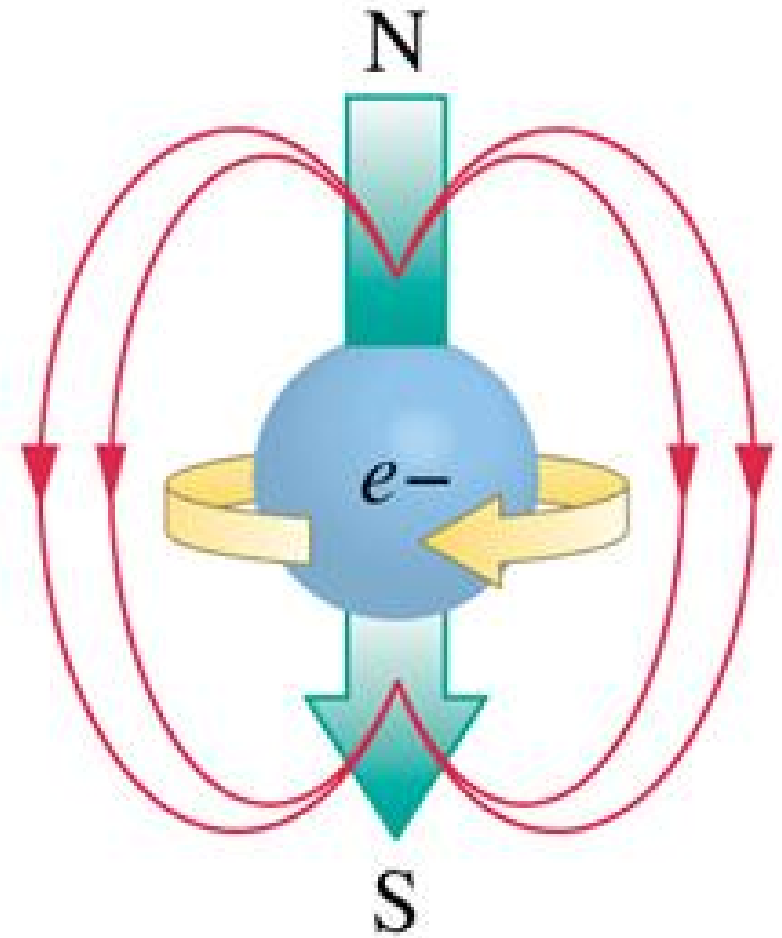




Ye olde magnetism



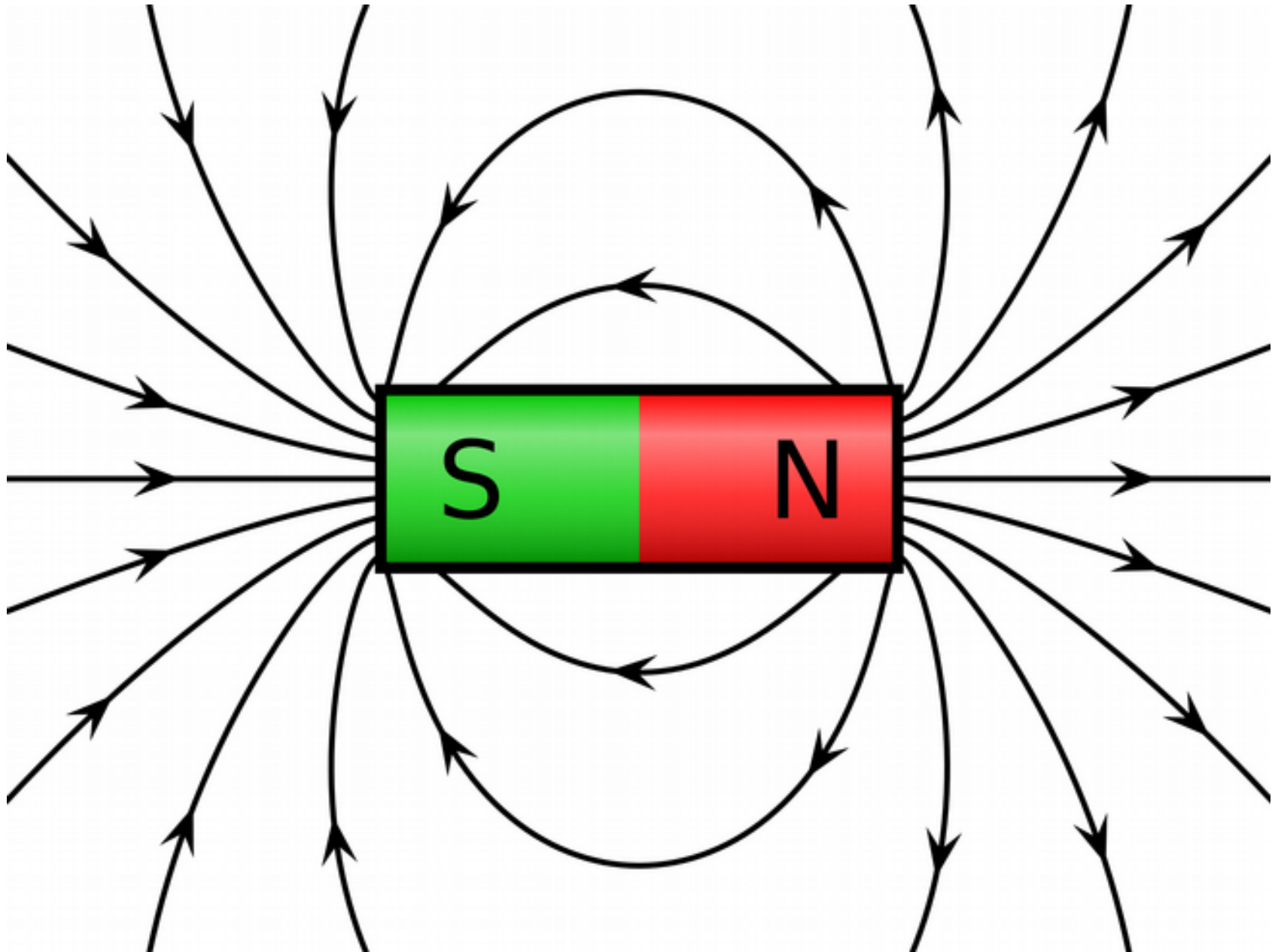
$$m_s = +\frac{1}{2}$$



$$m_s = -\frac{1}{2}$$

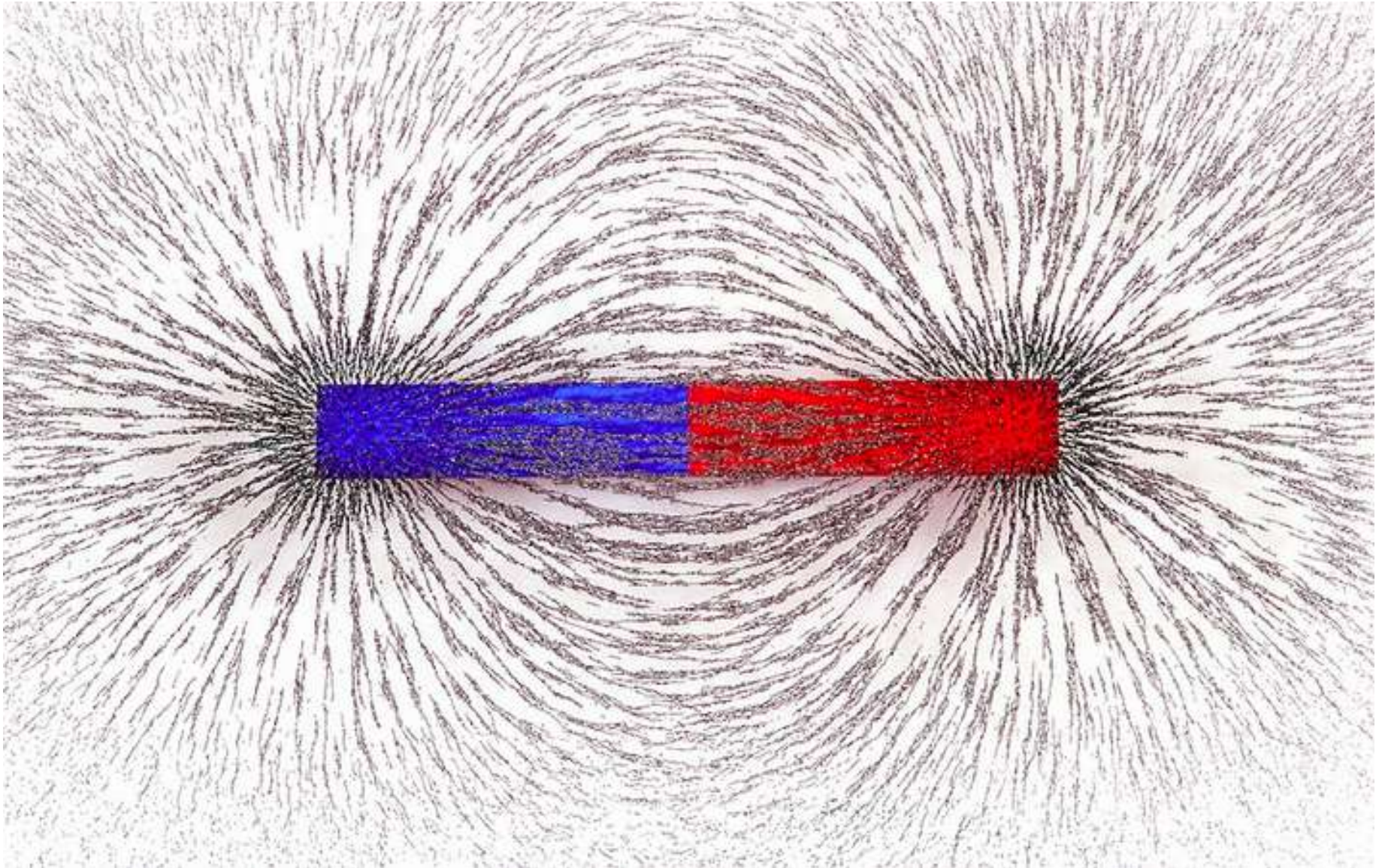


Ye olde magnetism



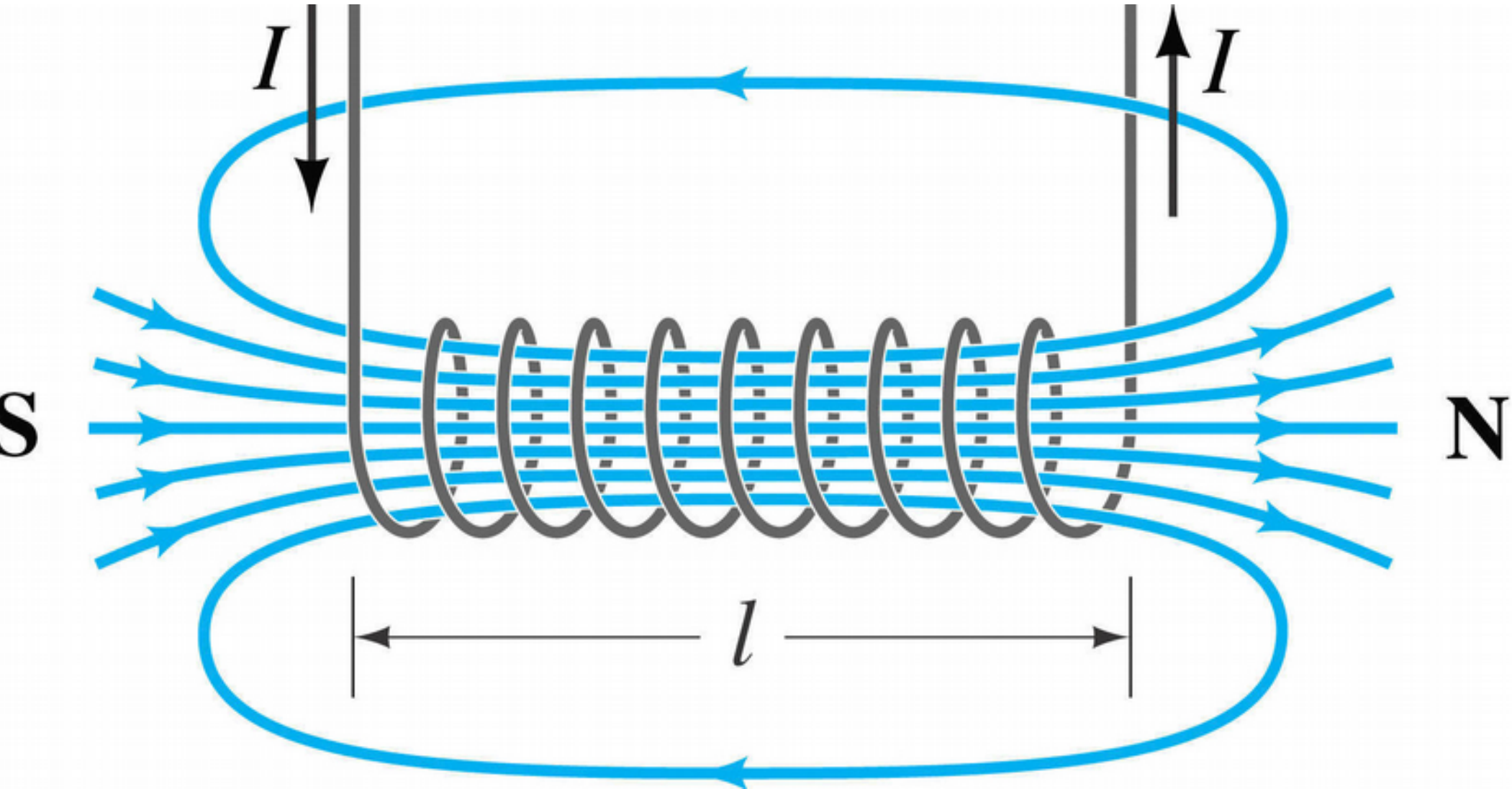


Ye olde magnetism



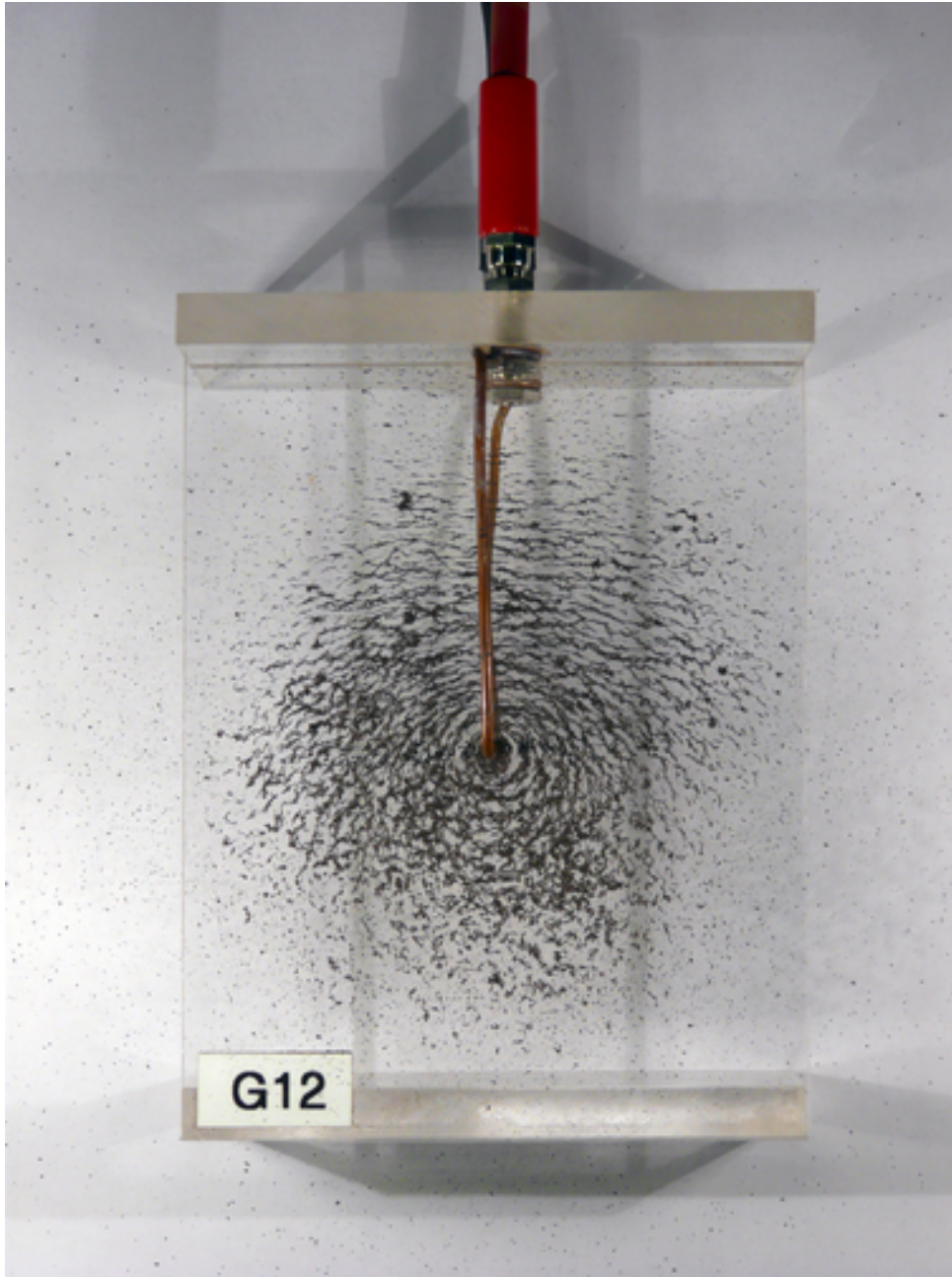


Ye olde magnetism

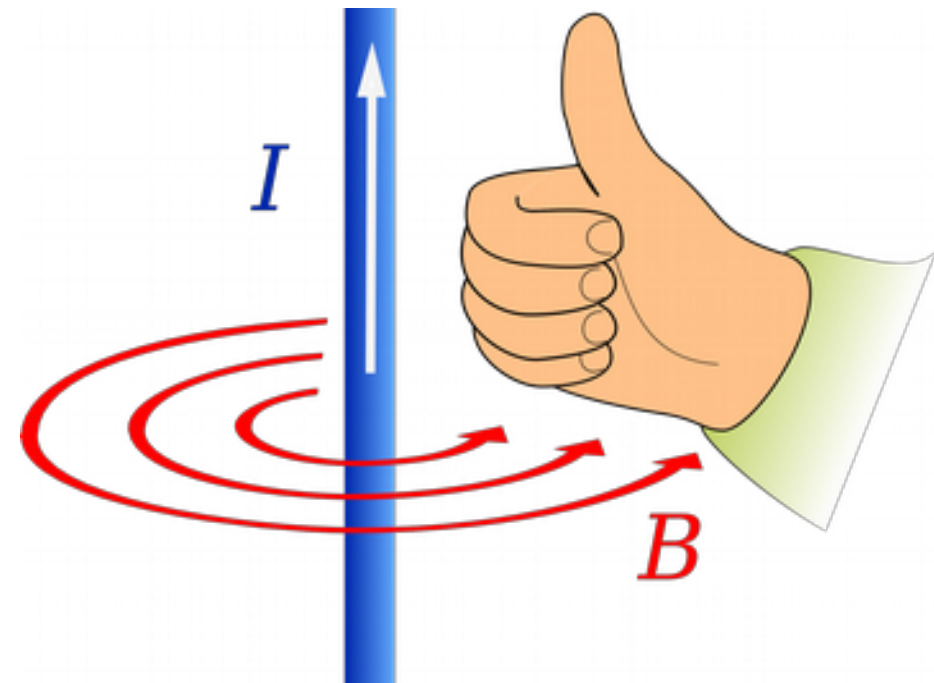




Ye olde magnetism

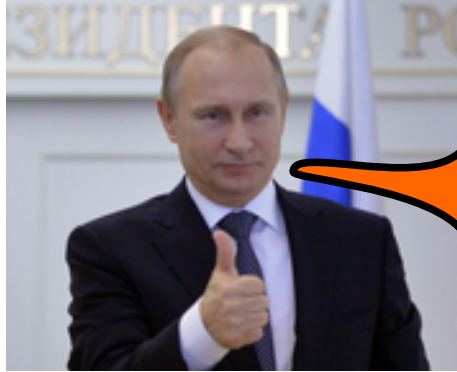
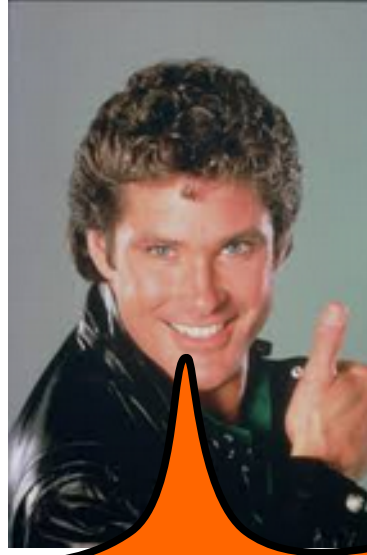


All moving charge, or “current” creates a magnetic field.

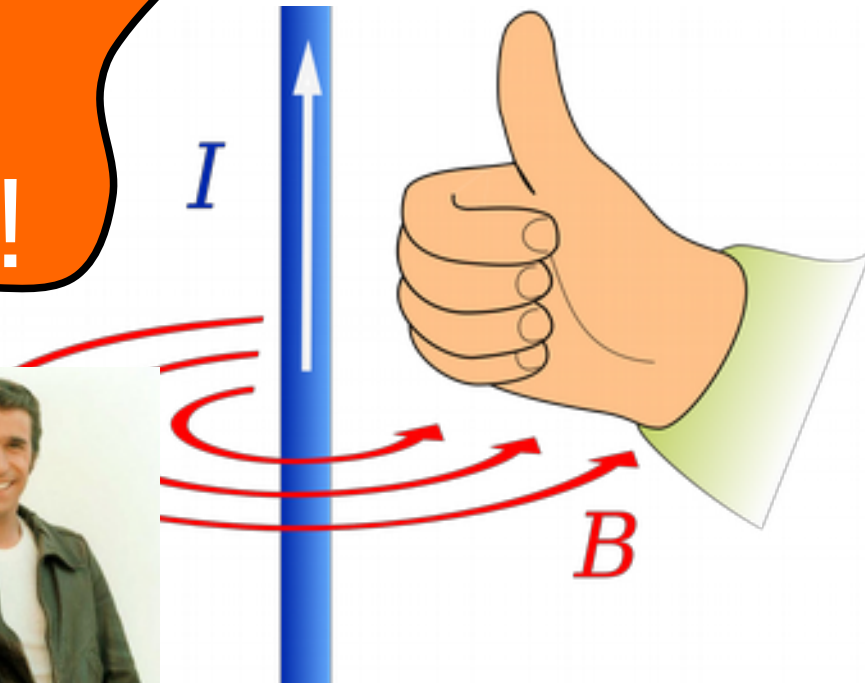




Ye olde magnetism

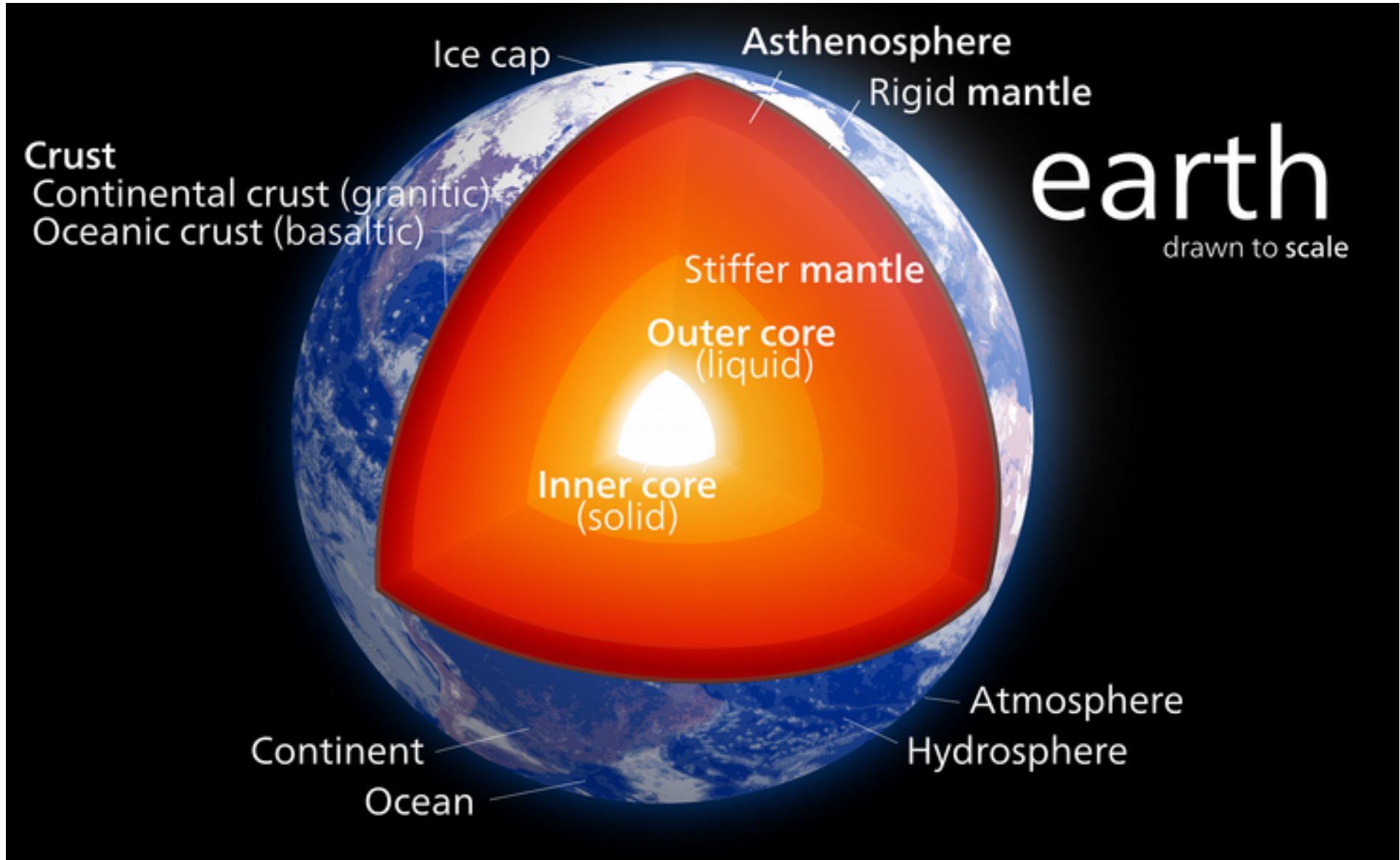


Current =
Magnetism!



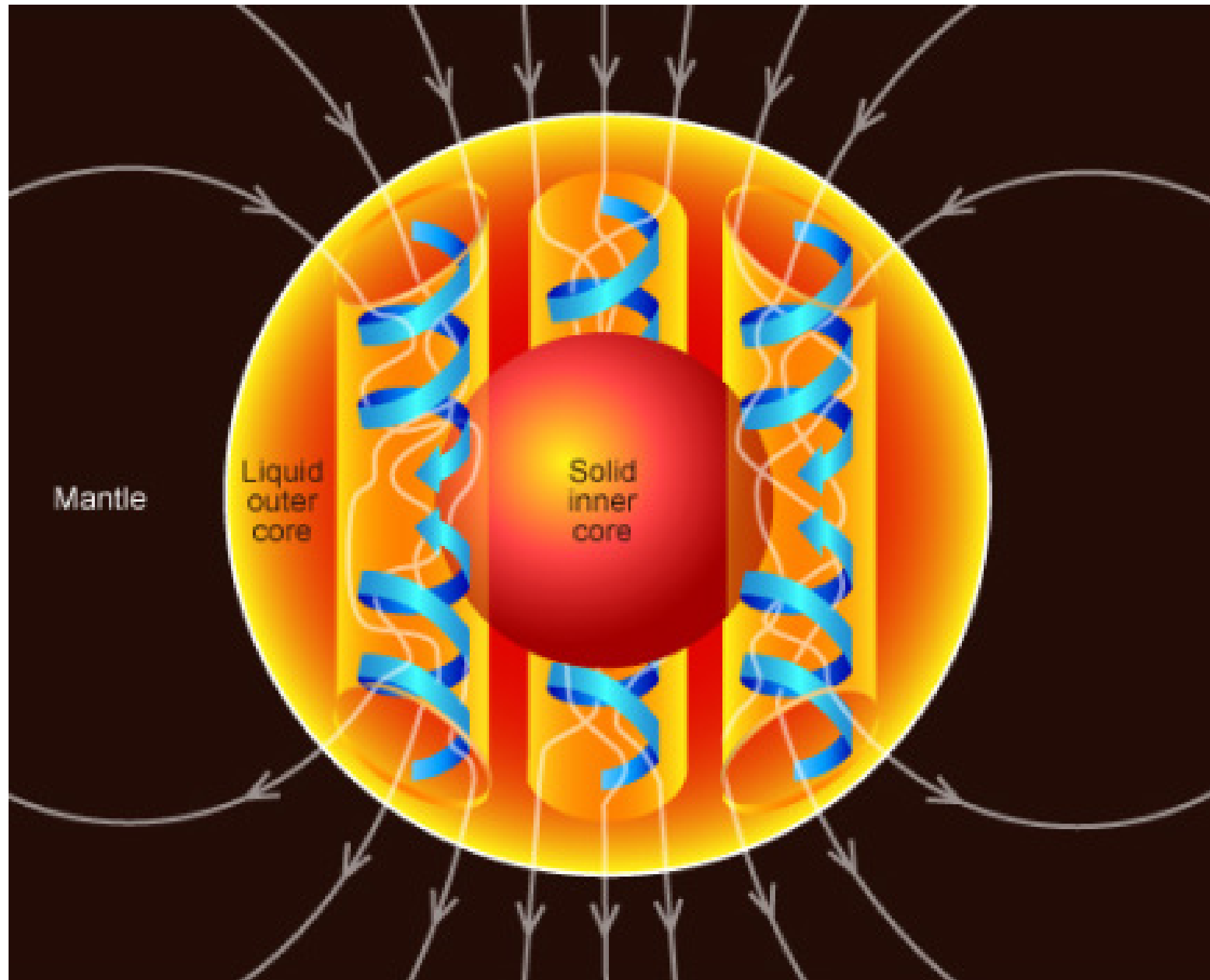


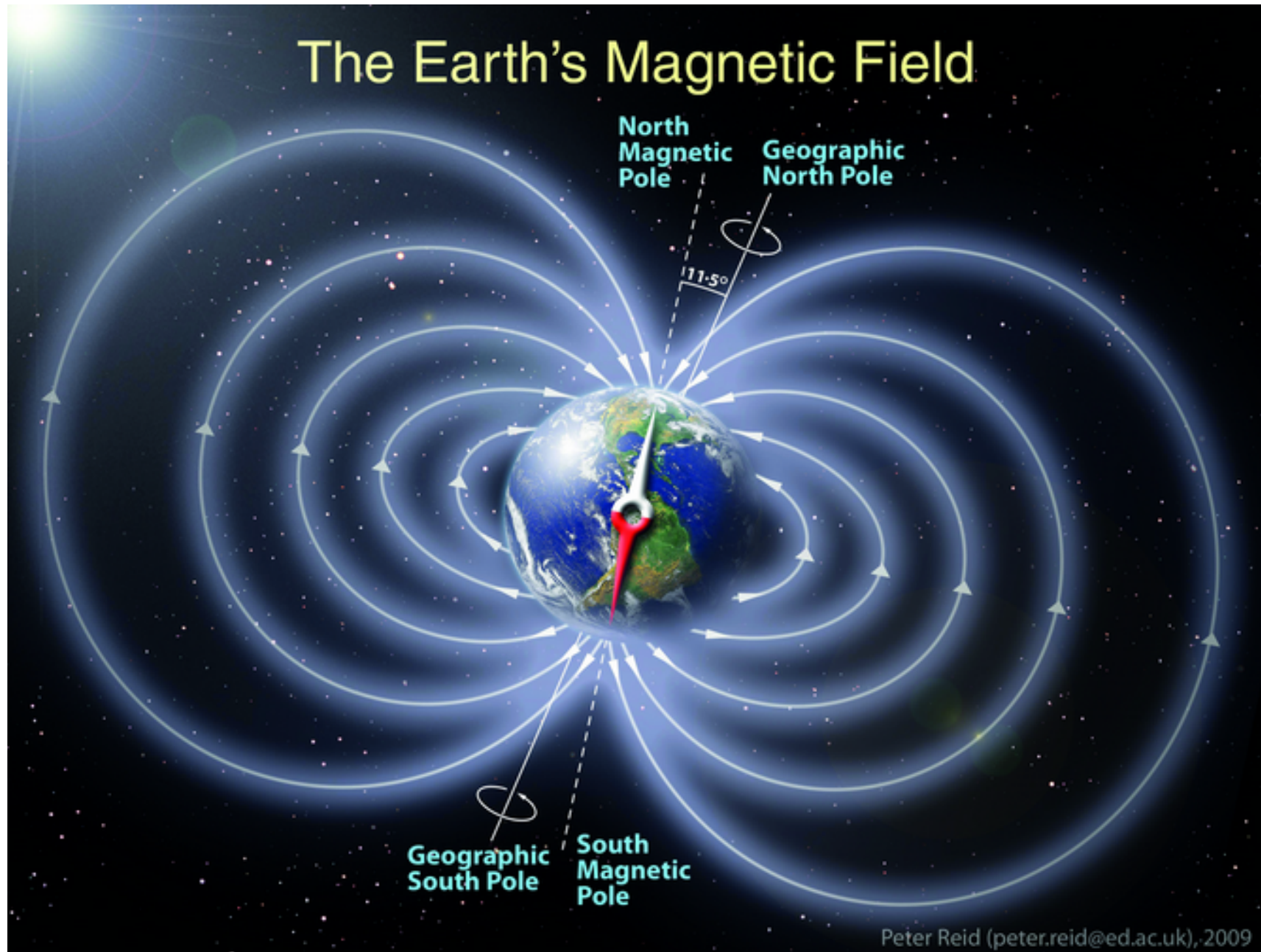
Magnetism on Earth and in the Sun





Magnetism on Earth and in the Sun

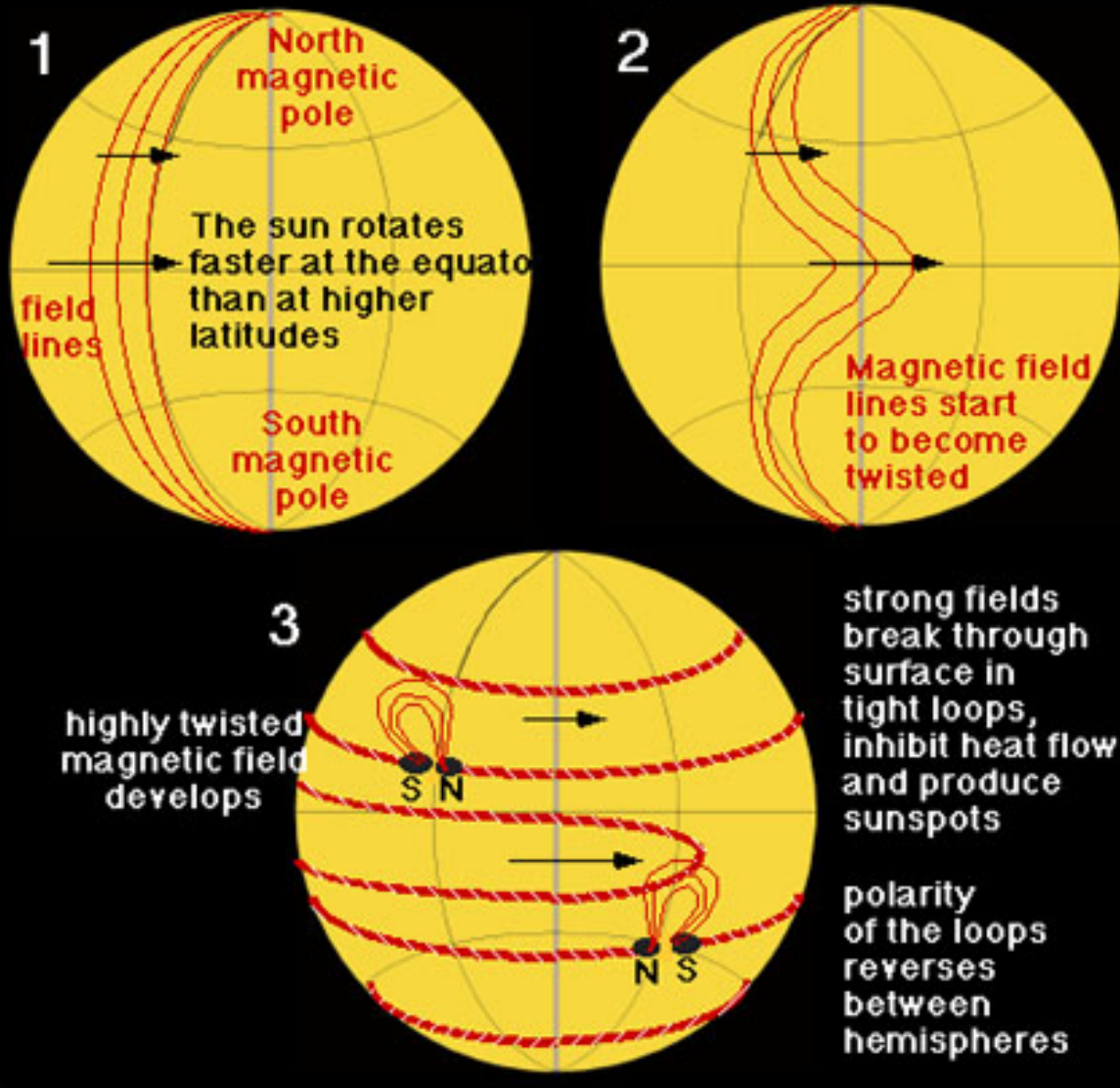






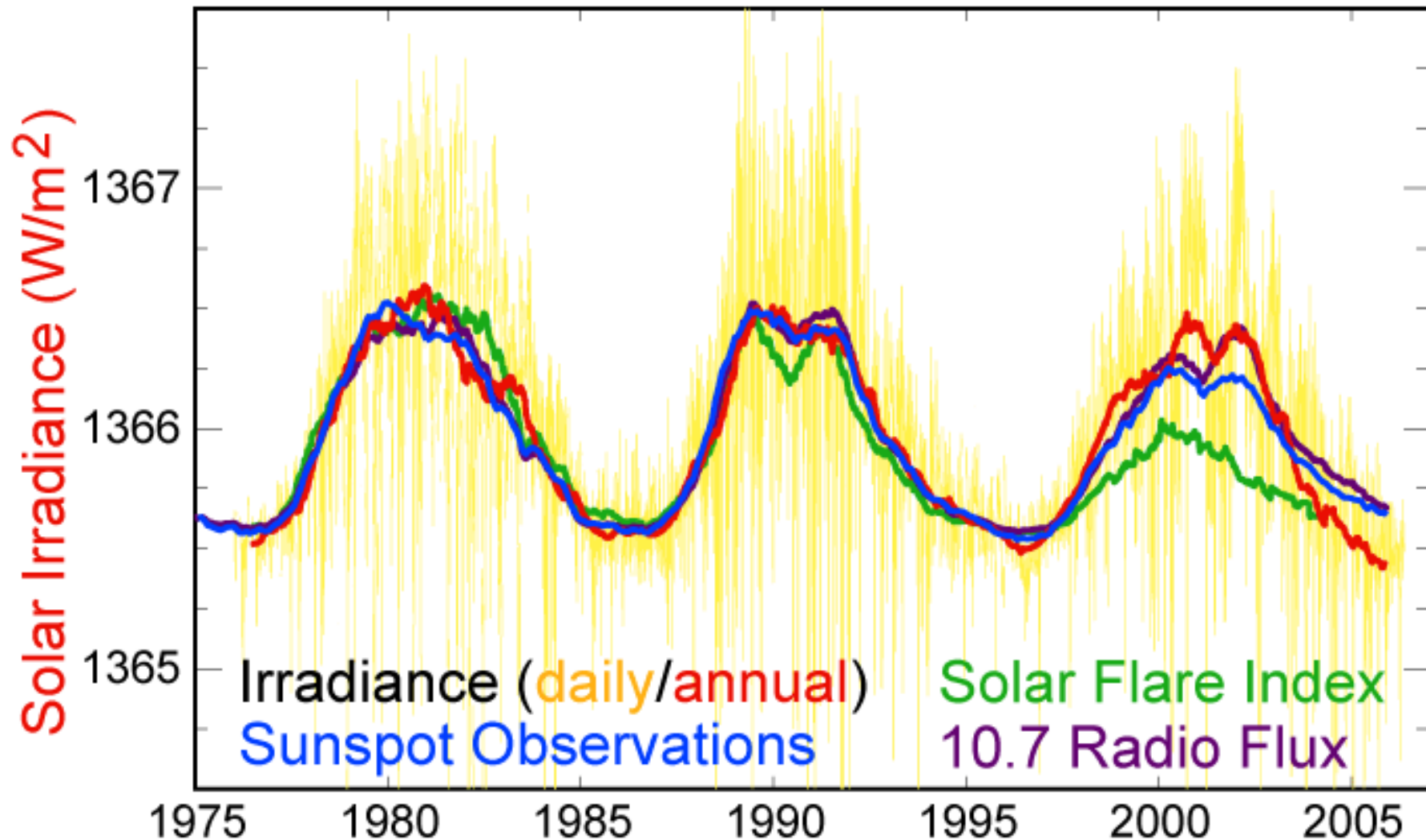
Magnetism on Earth and in the Sun

How Sunspots are Thought to Develop





Solar Cycle Variations



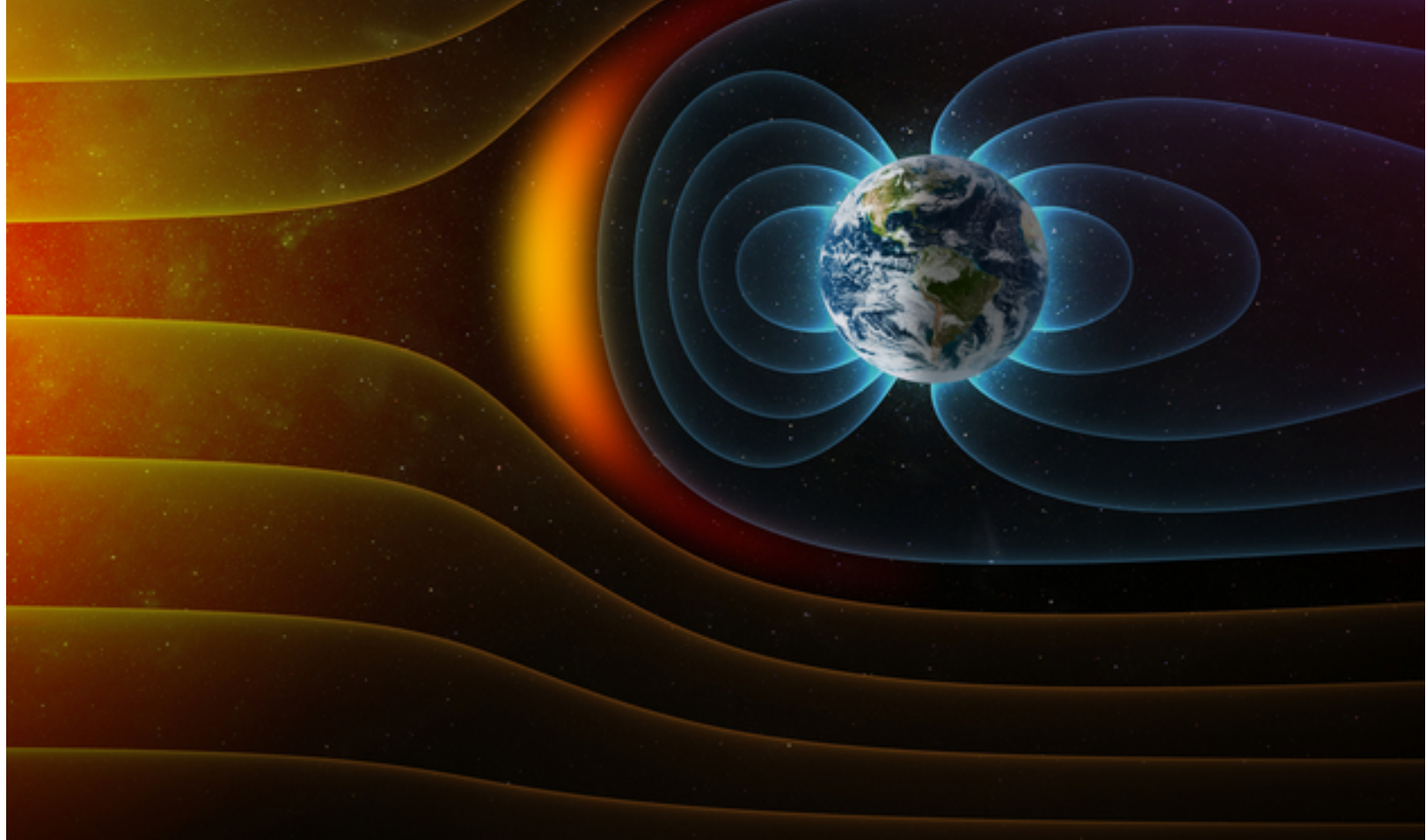


Magnetism on Earth and in the Sun



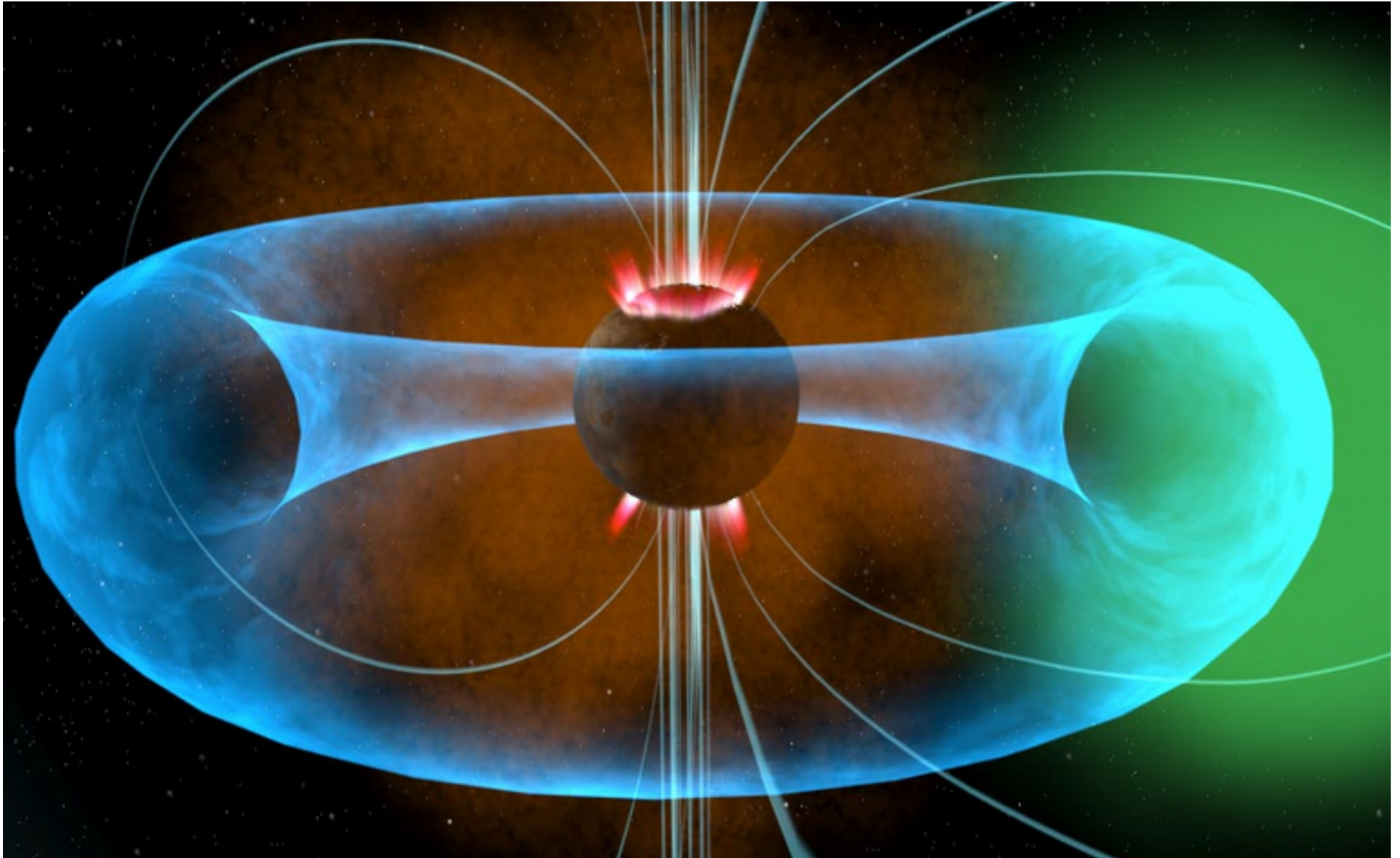


Magnetism on Earth and in the Sun





Magnetism on Earth and in the Sun





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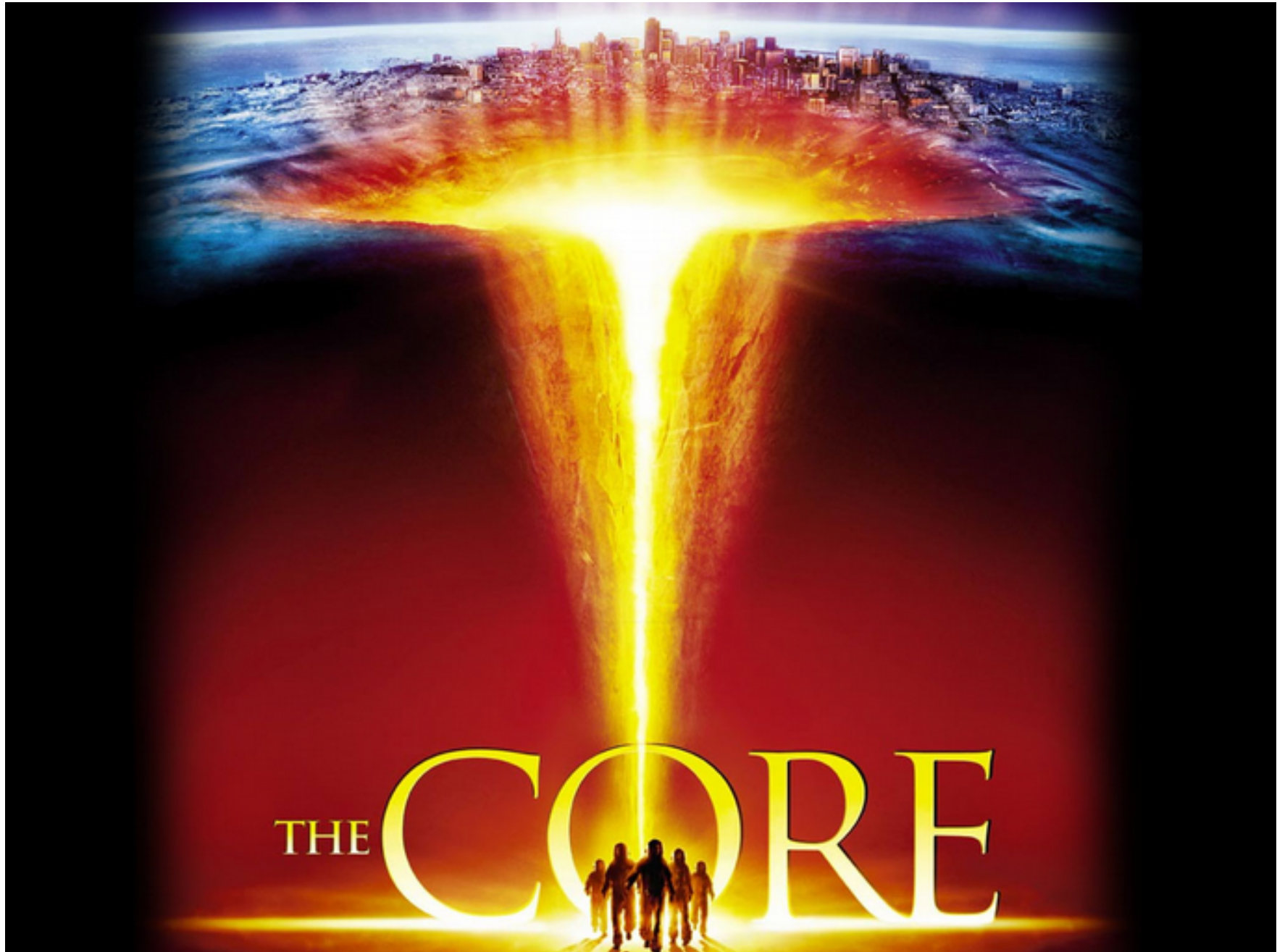
Magnetism on Earth and in the Sun





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Magnetism on Earth and in the Sun





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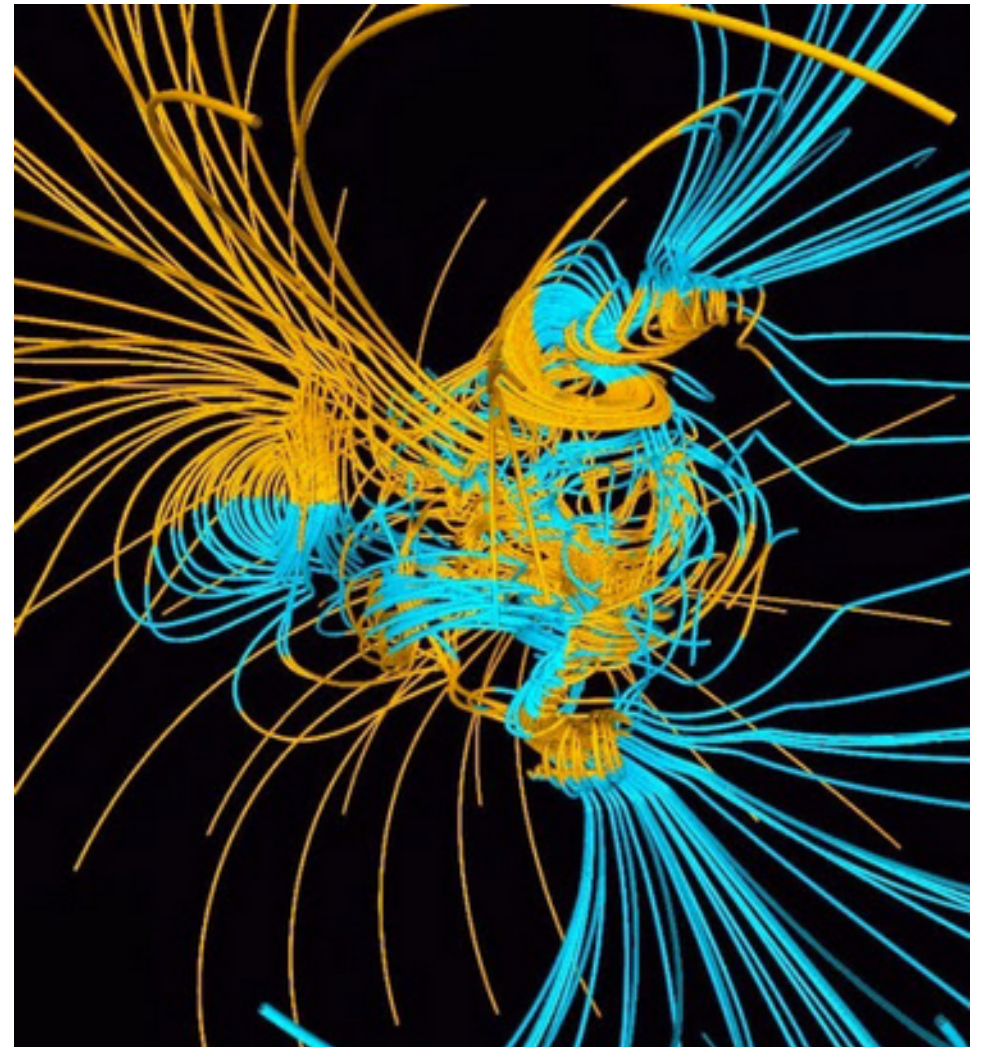
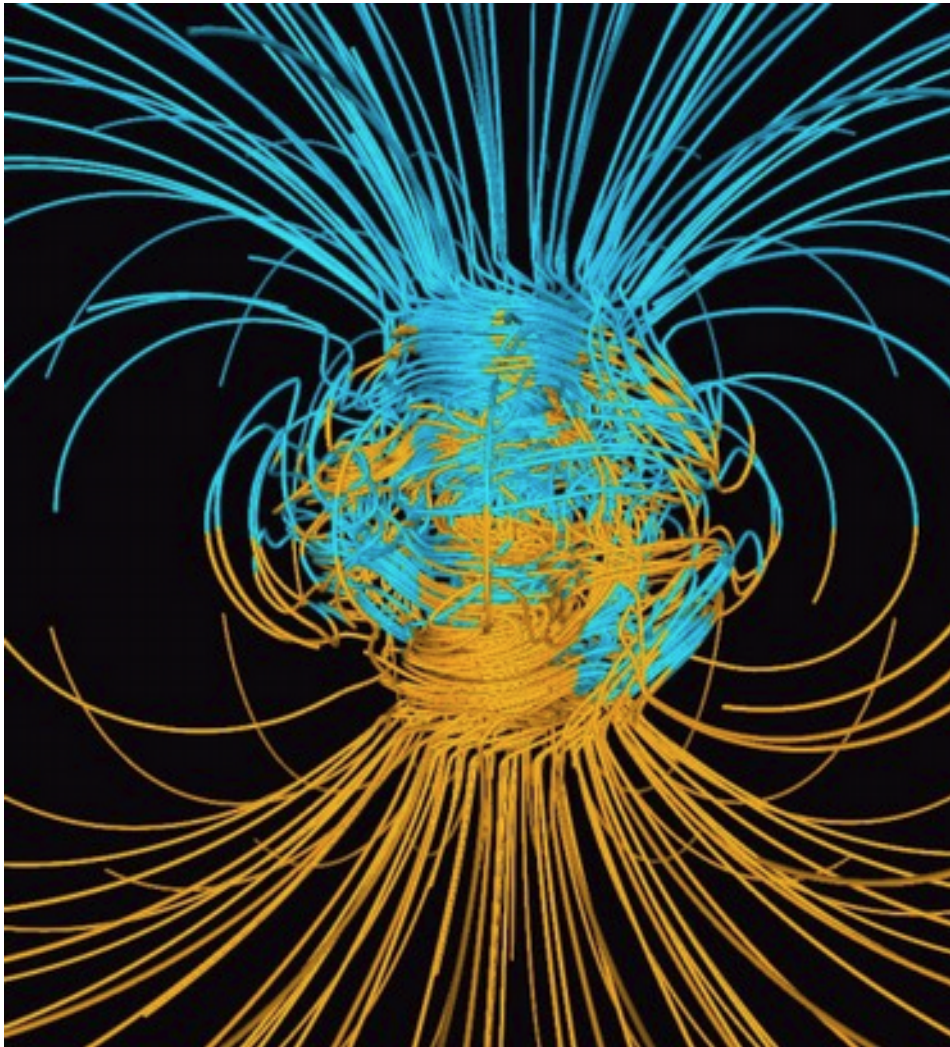
Magnetism on Earth and in the Sun

2012



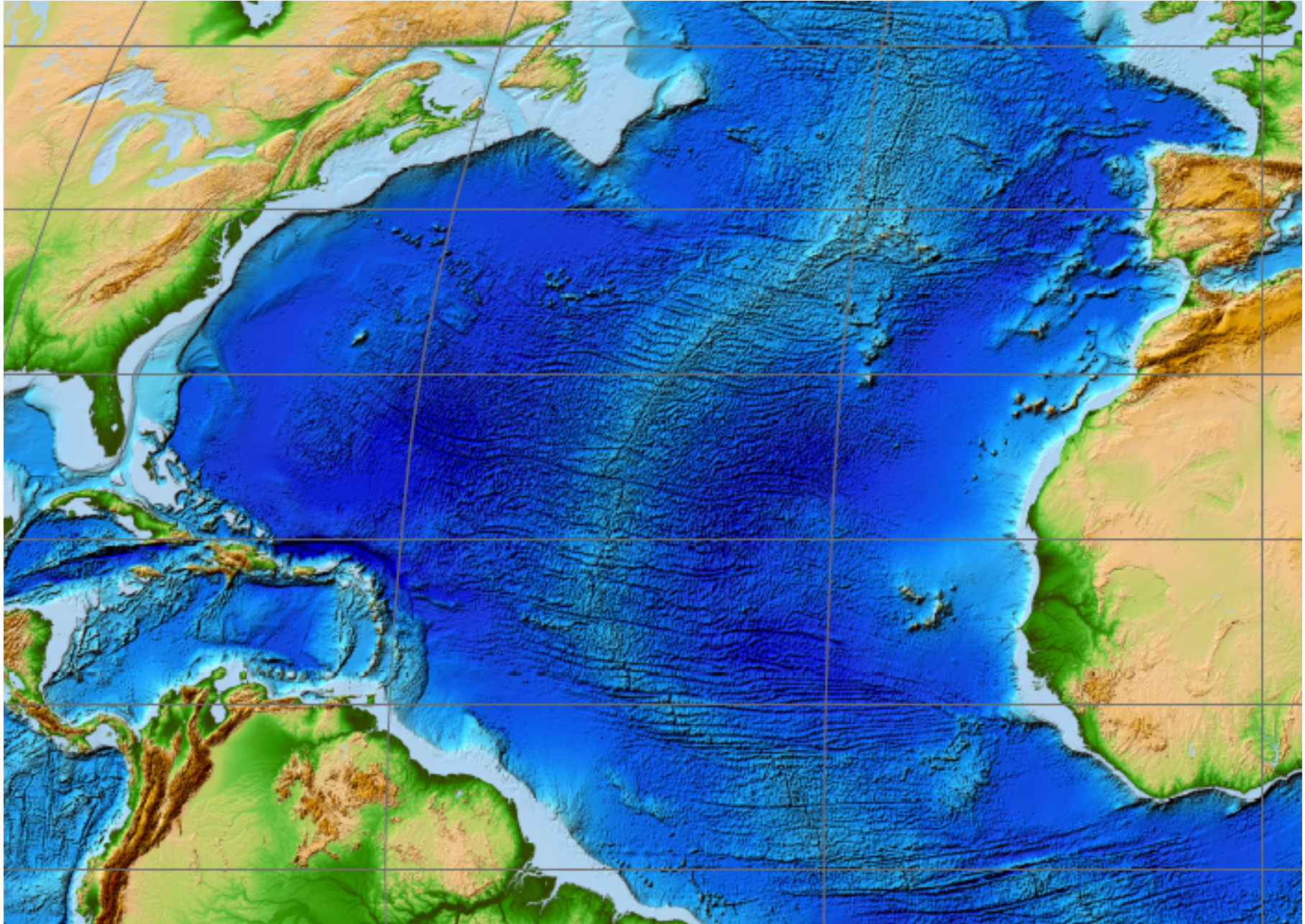


Magnetism on Earth and in the Sun



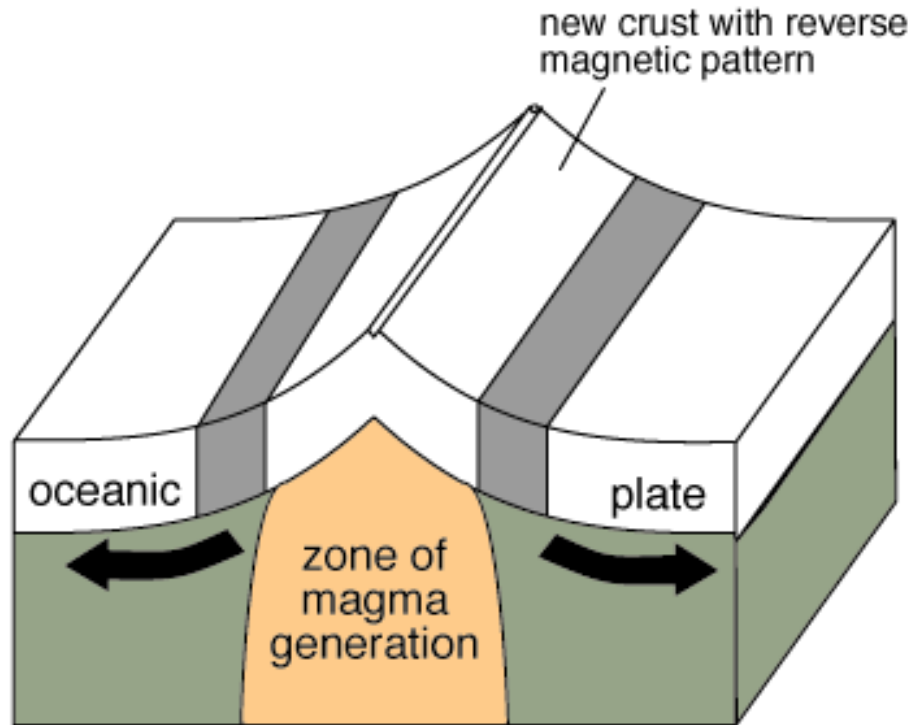


Magnetism on Earth and in the Sun

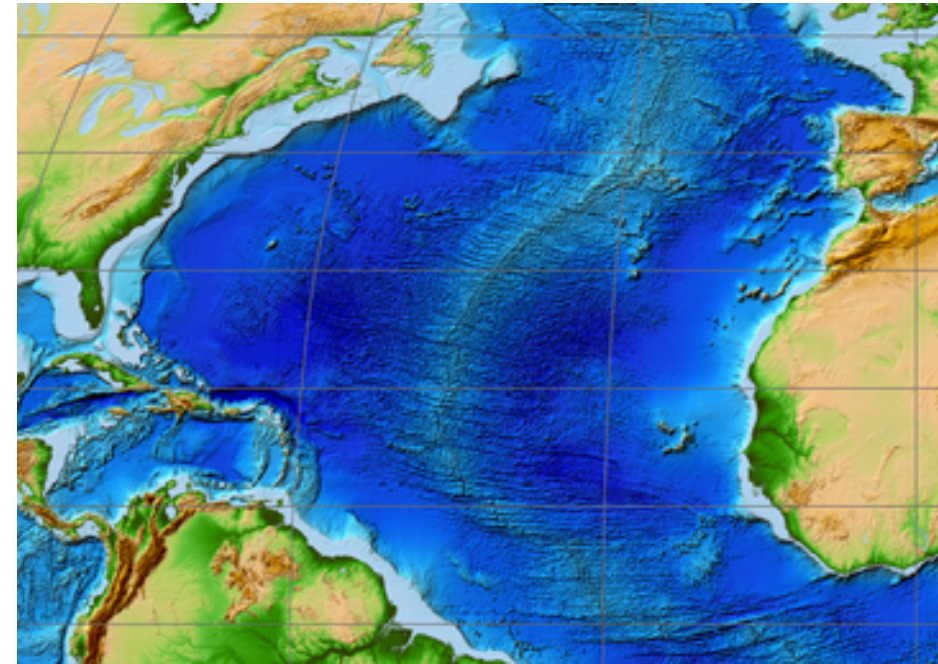




Magnetism on Earth and in the Sun



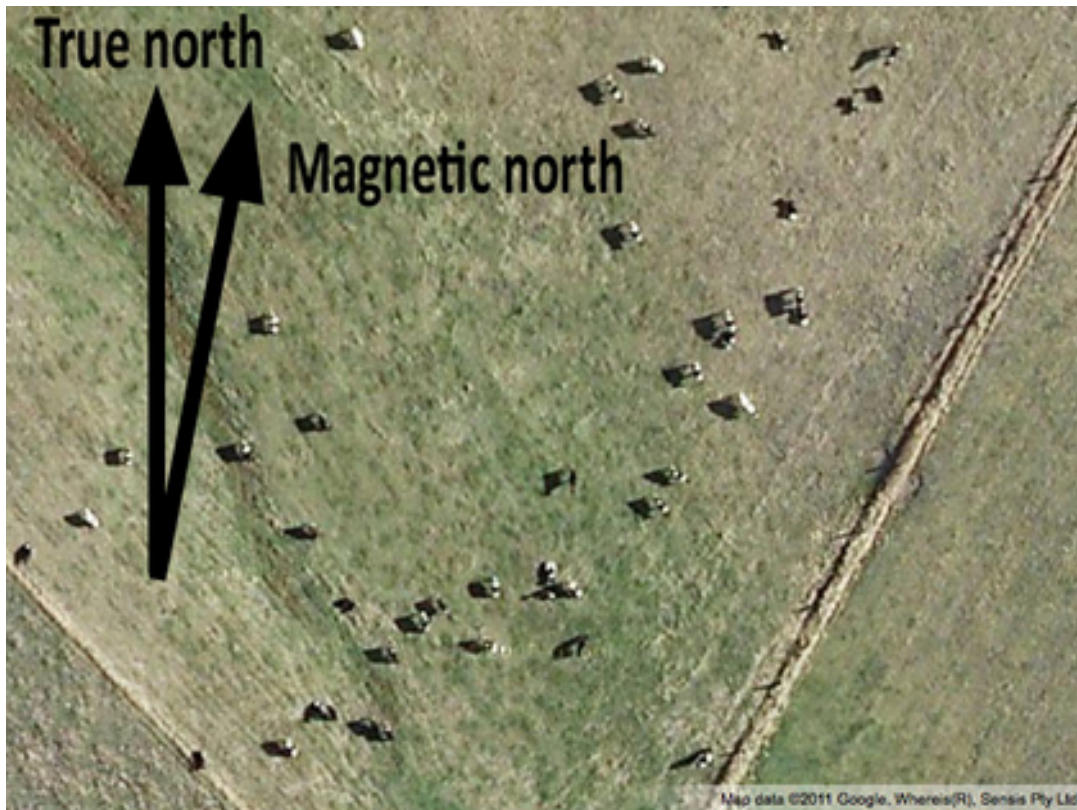
If the magnetic pole is in the southern hemisphere, the rocks record a reverse magnetic pattern.





Magnetic alignment in grazing and resting cattle and deer

Sabine Begall^{*,†}, Jaroslav Červený^{‡,§}, Julia Neef^{*}, Oldřich Vojtěch^{‡,¶}, and Hynek Burda^{*}





Hart et al. *Frontiers in Zoology* 2013, **10**:80
<http://www.frontiersinzoology.com/content/10/1/80>



FRONTIERS IN ZOOLOGY

RESEARCH

Open Access

Dogs are sensitive to small variations of the Earth's magnetic field

Vlastimil Hart¹, Petra Nováková¹, Erich Pascal Malkemper^{2†}, Sabine Begall^{2†}, Vladimír Hanzal¹, Miloš Ježek¹, Tomáš Kušta¹, Veronika Němcová¹, Jana Adámková¹, Kateřina Benediktová¹, Jaroslav Červený¹ and Hynek Burda^{1,2*}

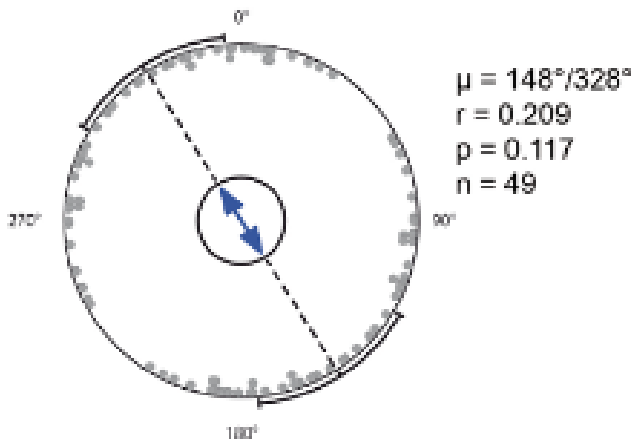


Magnetism on Earth and in the Sun

“Dogs preferred to excrete with the body being aligned along the North–South axis ...”

Defecation

total data

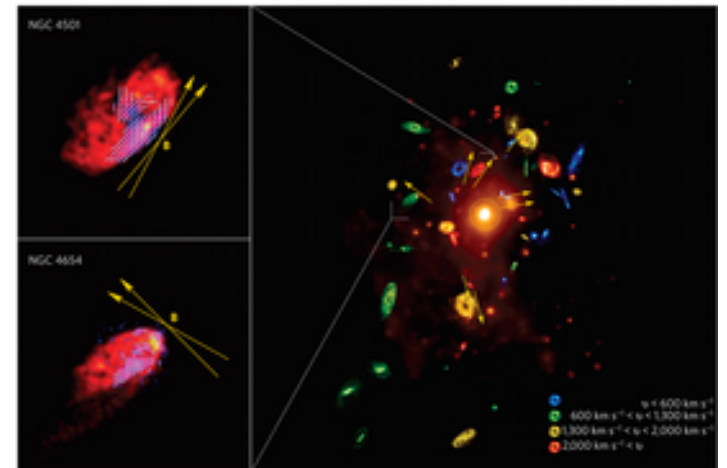
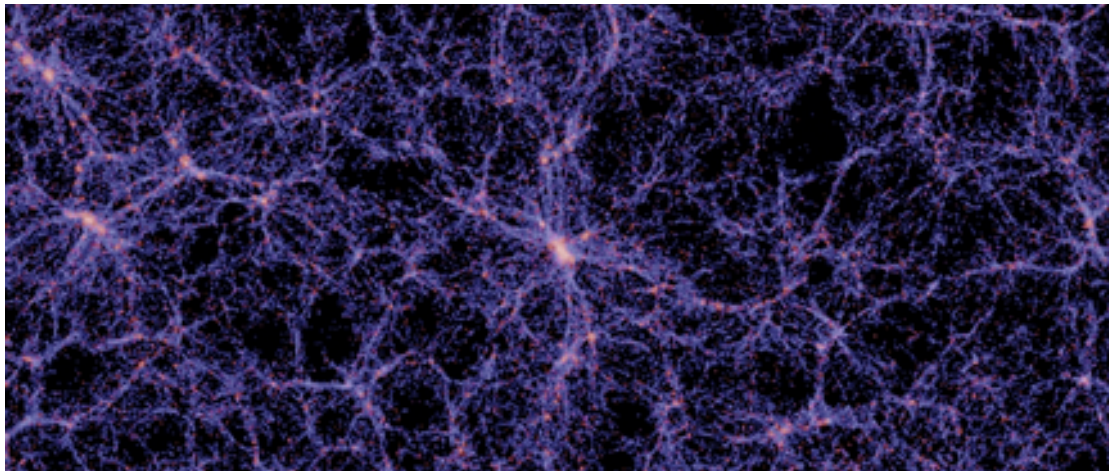
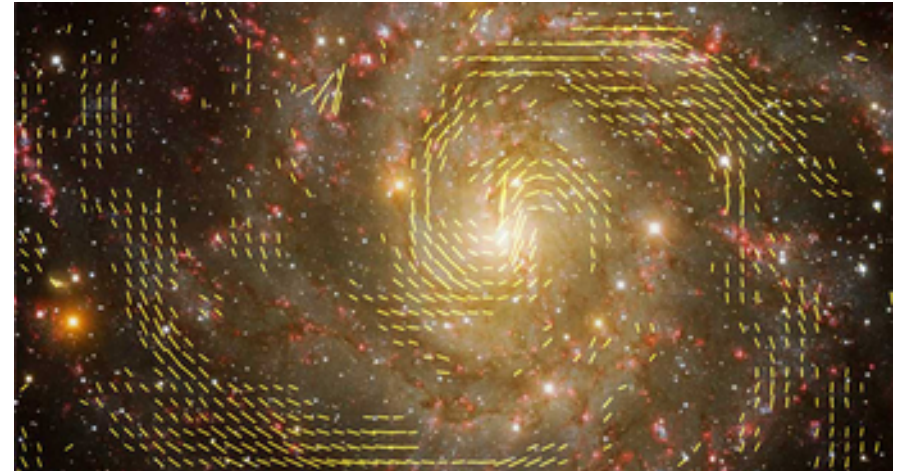
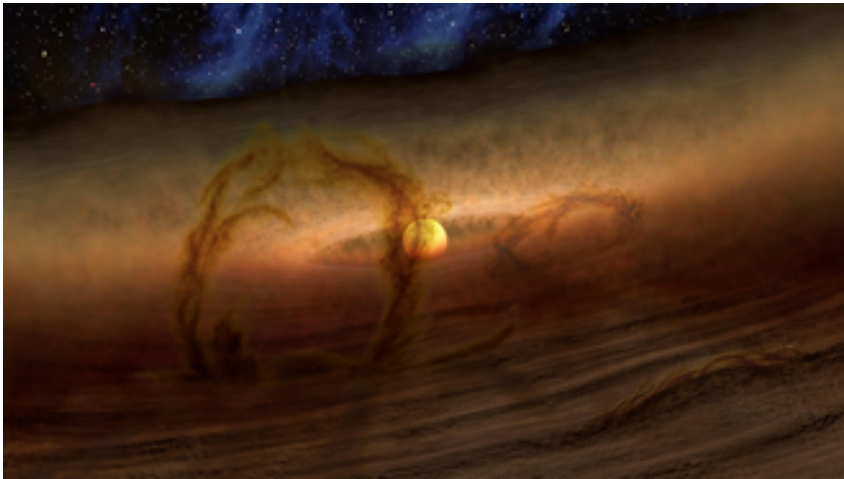


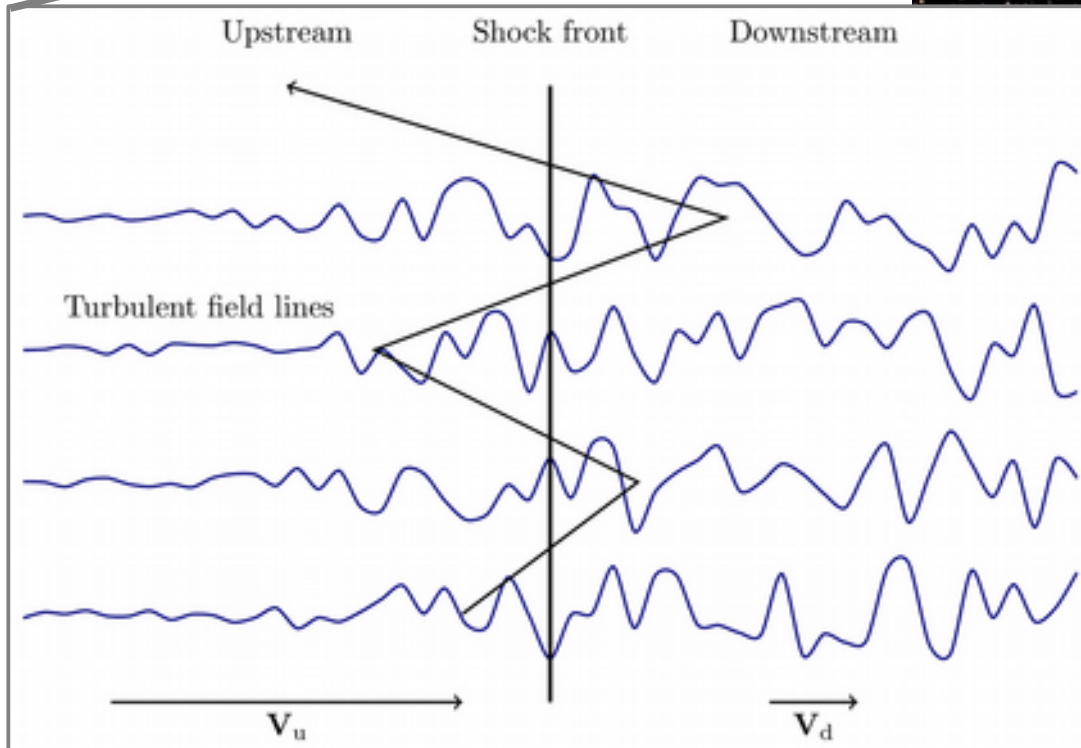
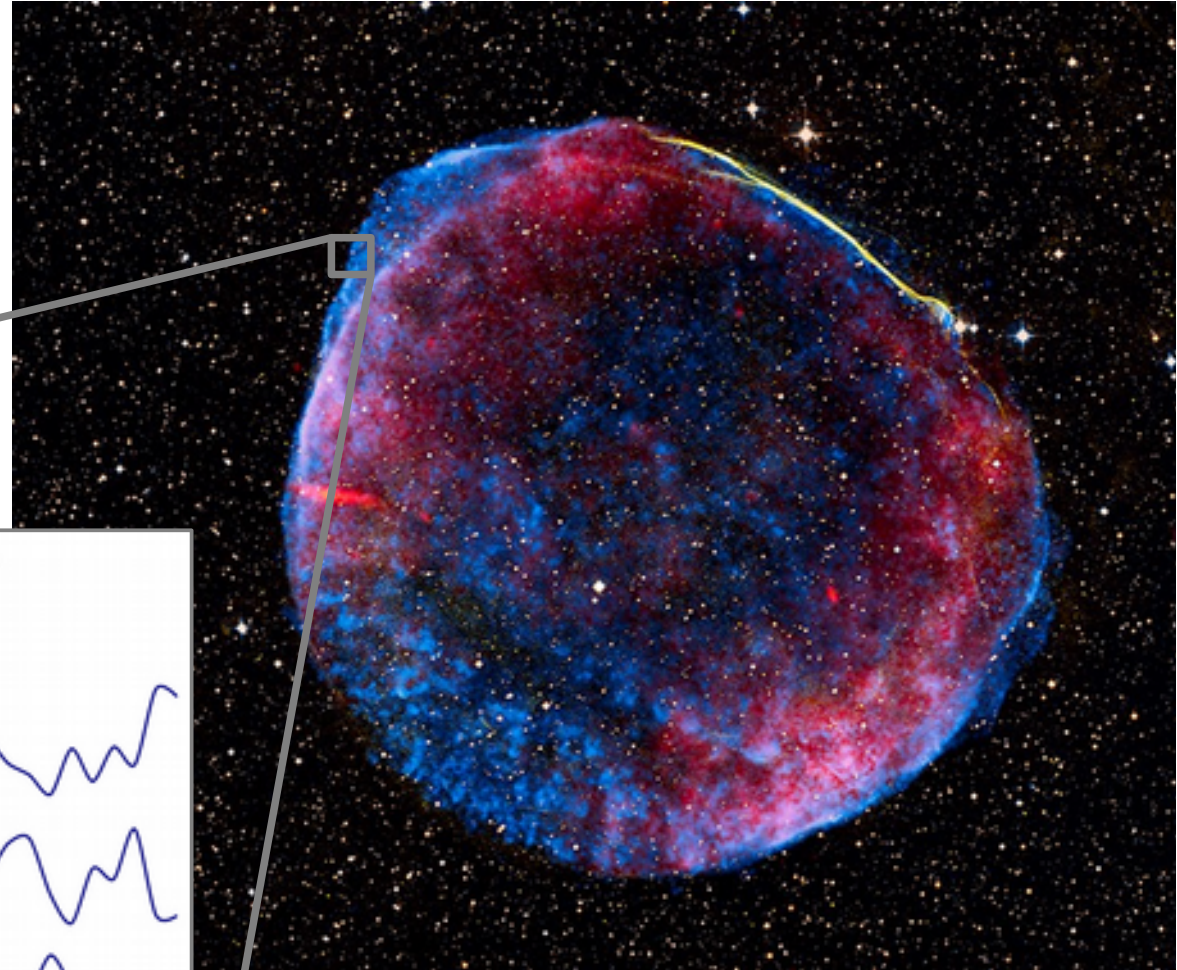


Magnetism in Space

Why do we care about magnetism in space?

- Magnetic fields are *everywhere in space!*







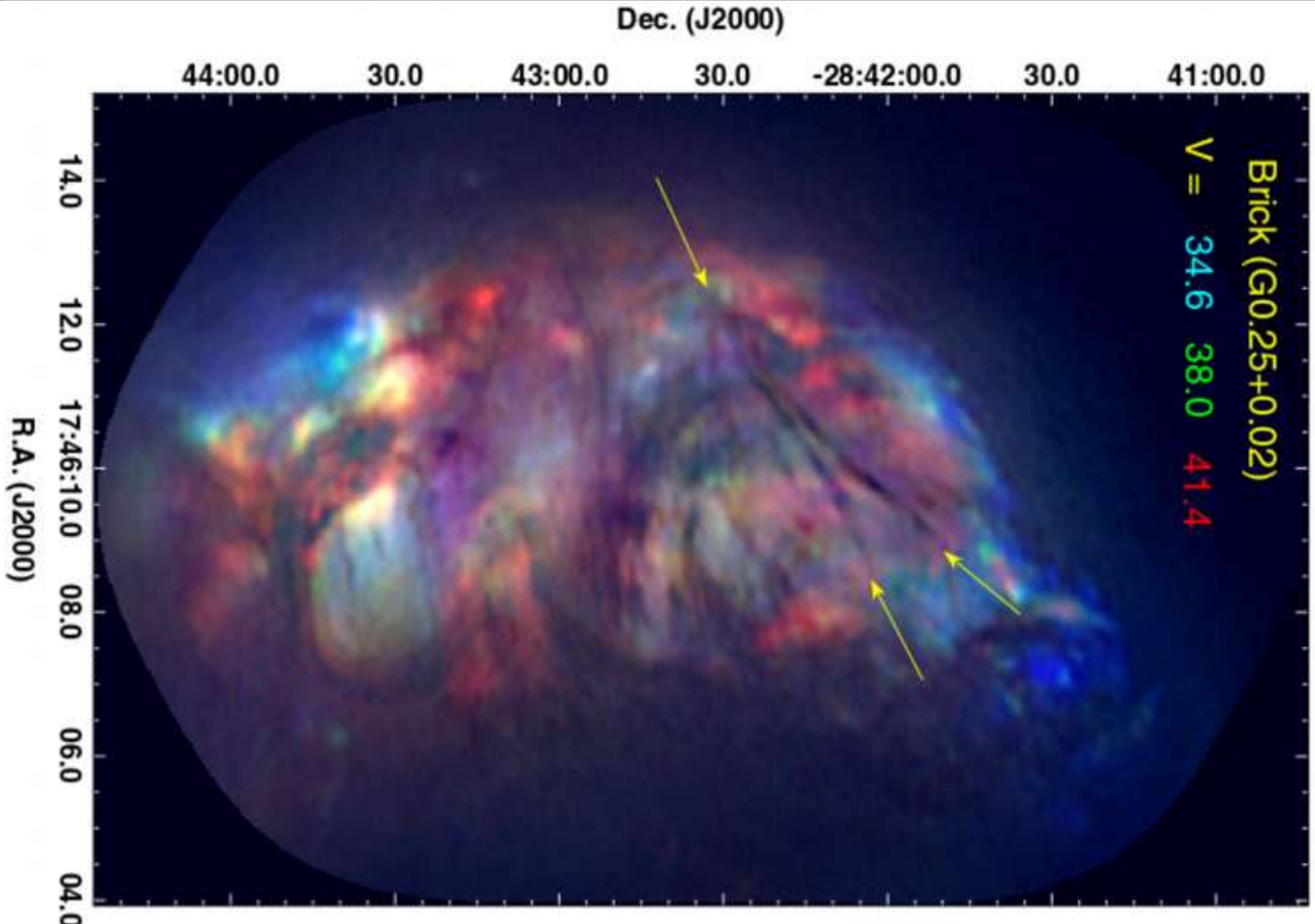
Magnetism in Space

Image credit: NRAO Adam Ginsburg and John Bally (Univ of Colorado - Boulder), Farhad Yusef-Zadeh (Northwestern), Bolocam Galactic Plane Survey team; GLIMPSE II team



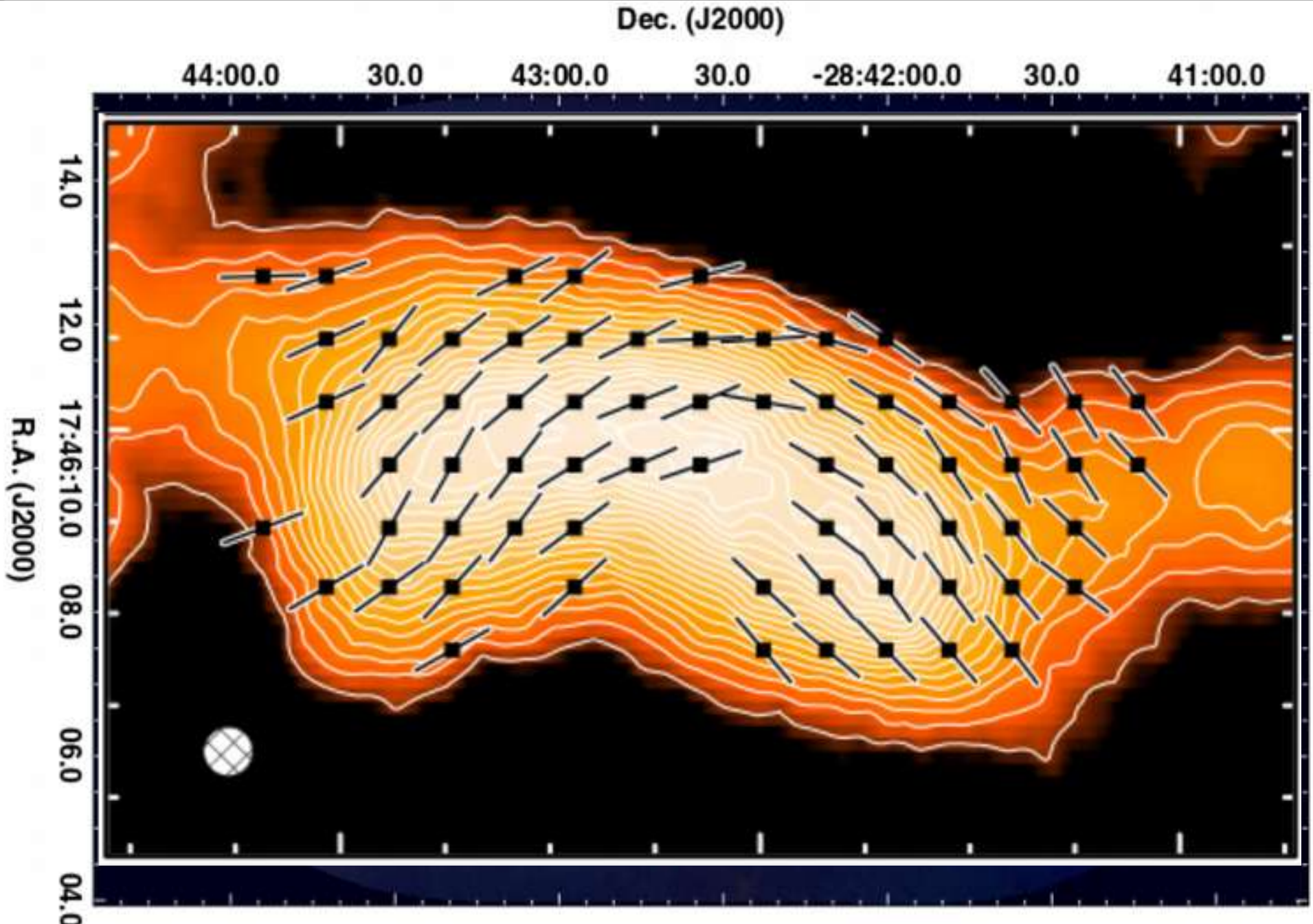


Magnetism in Space



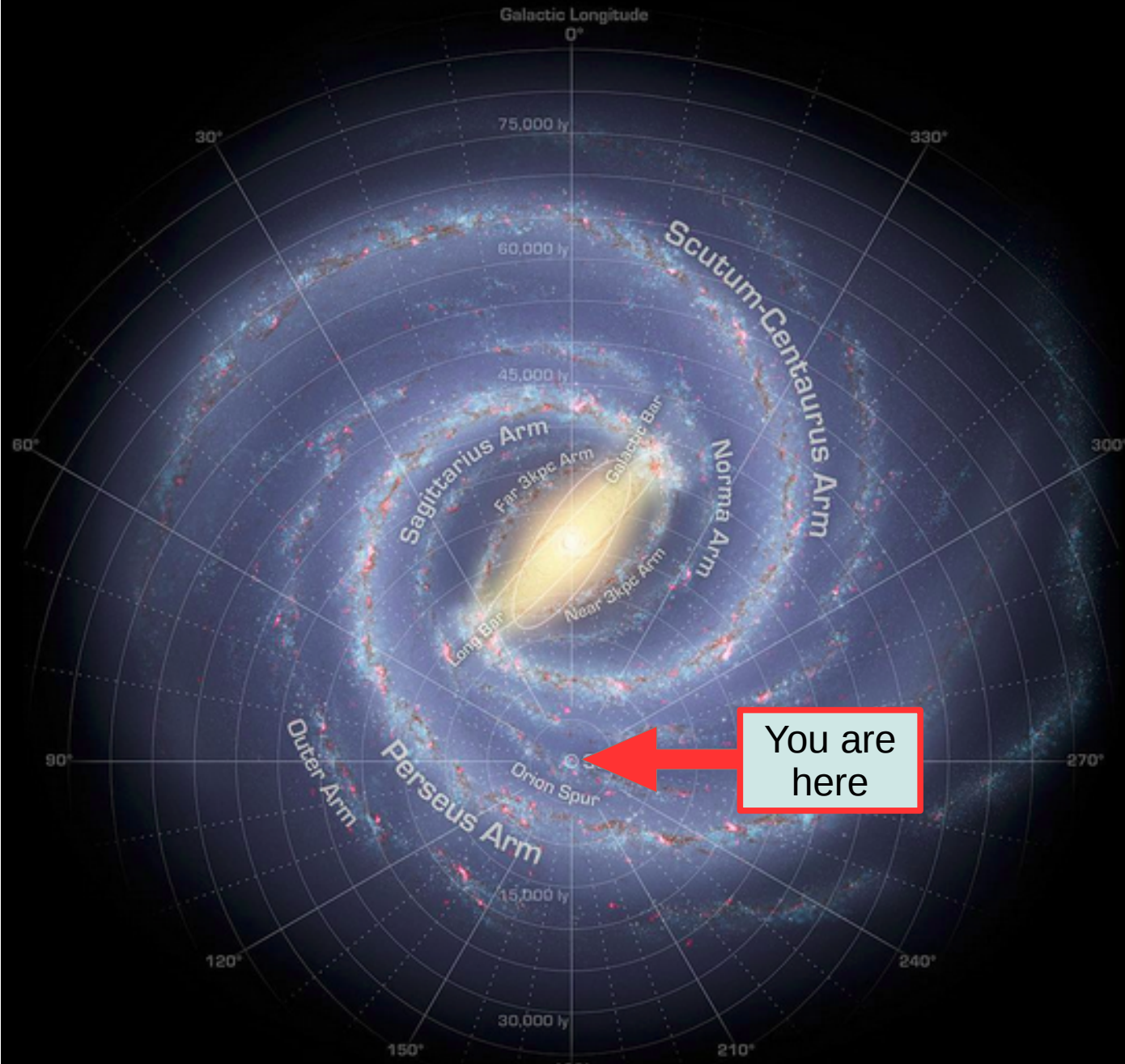


Magnetism in Space





Magnetism in our Galaxy





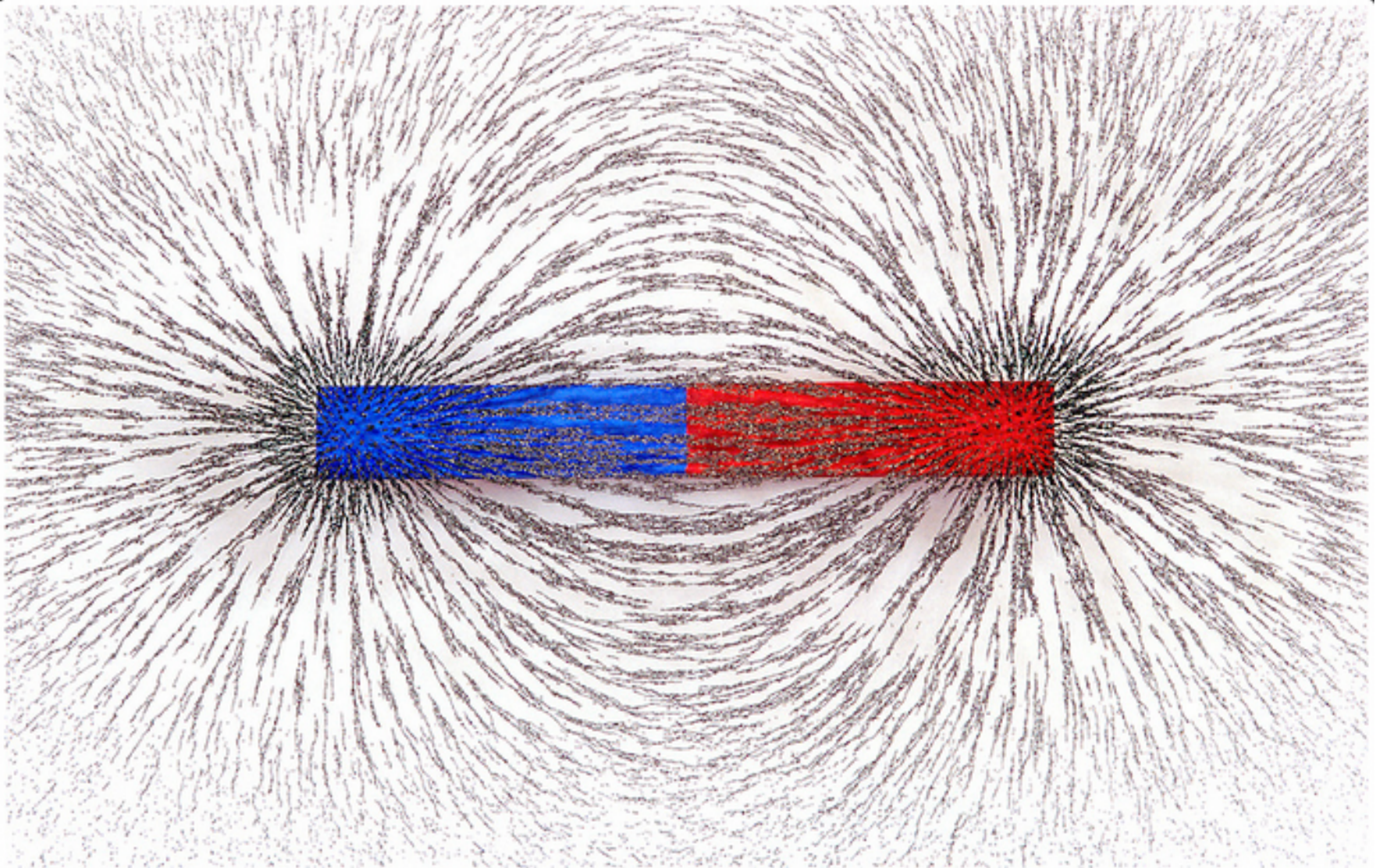
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Magnetism in our Galaxy



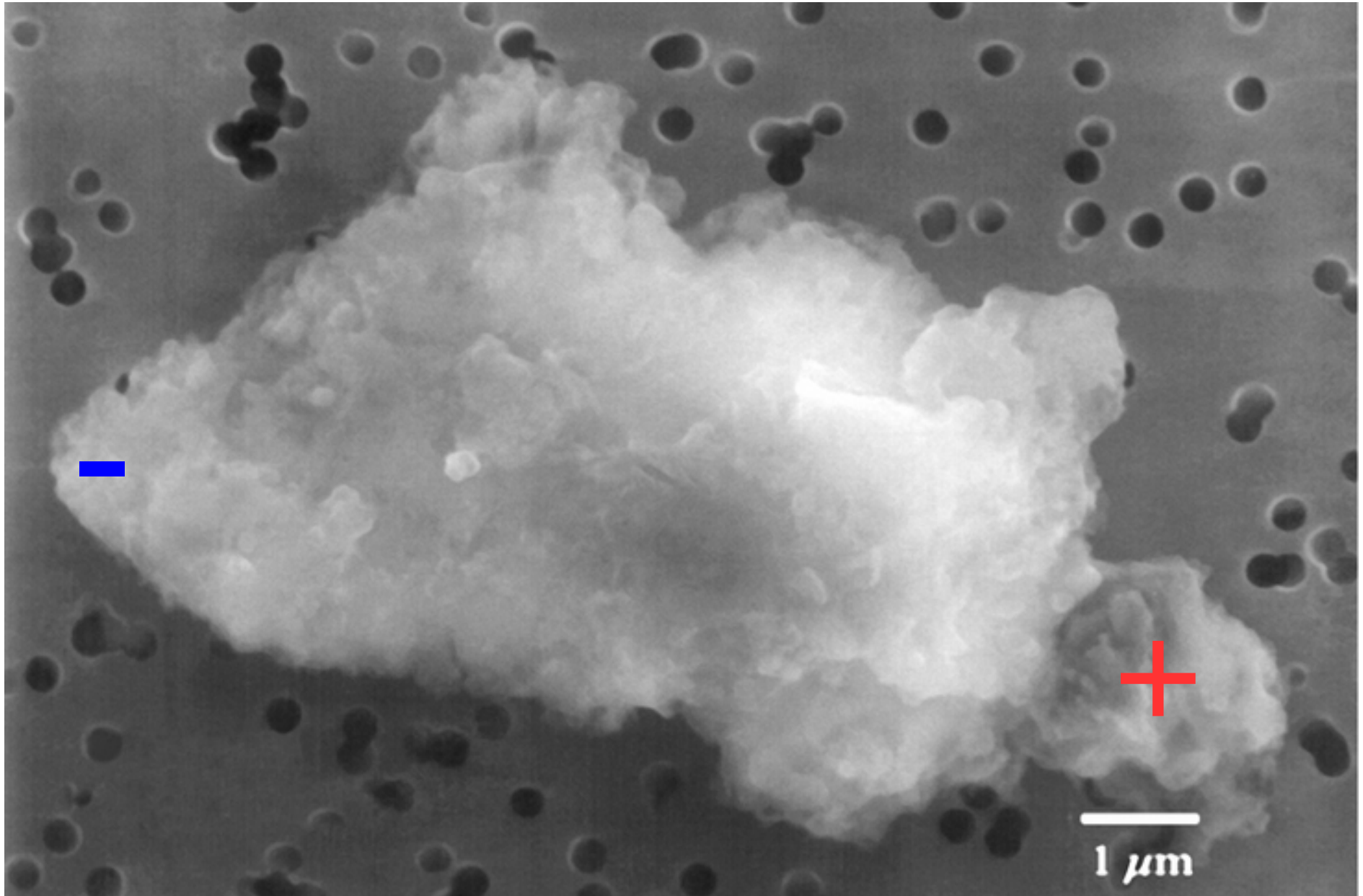


Magnetism in our Galaxy



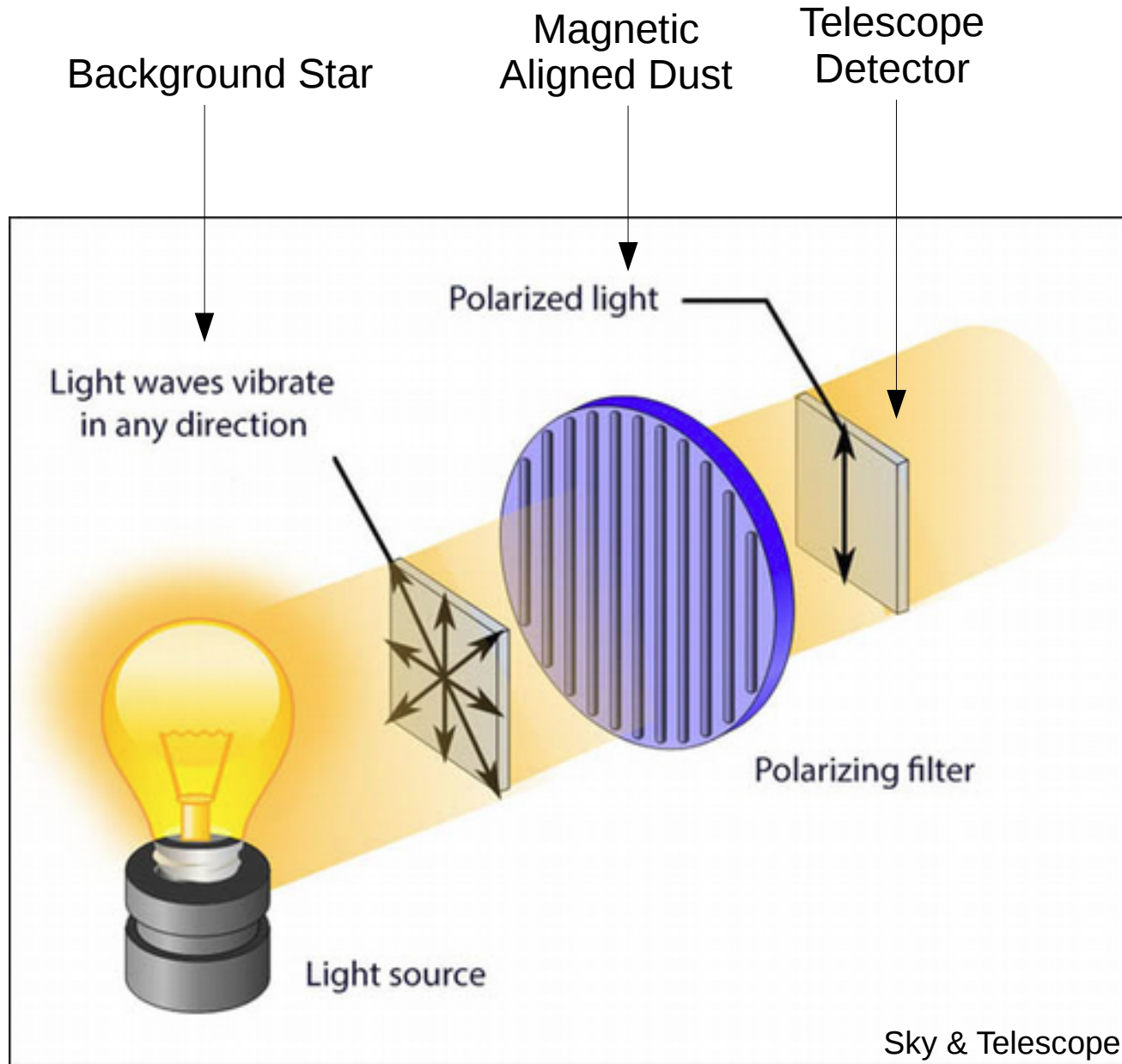


Magnetism in our Galaxy



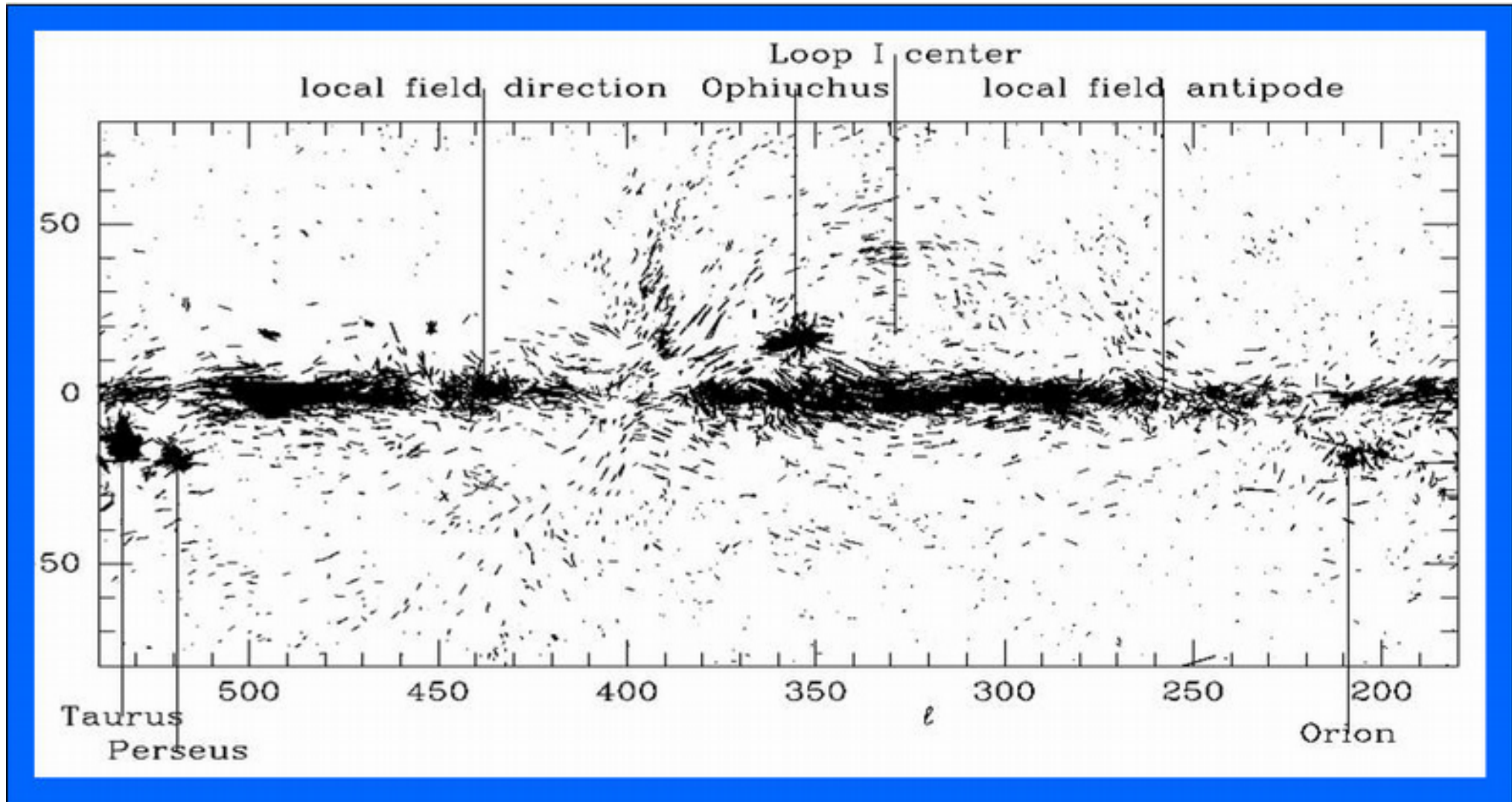


Magnetism in our Galaxy





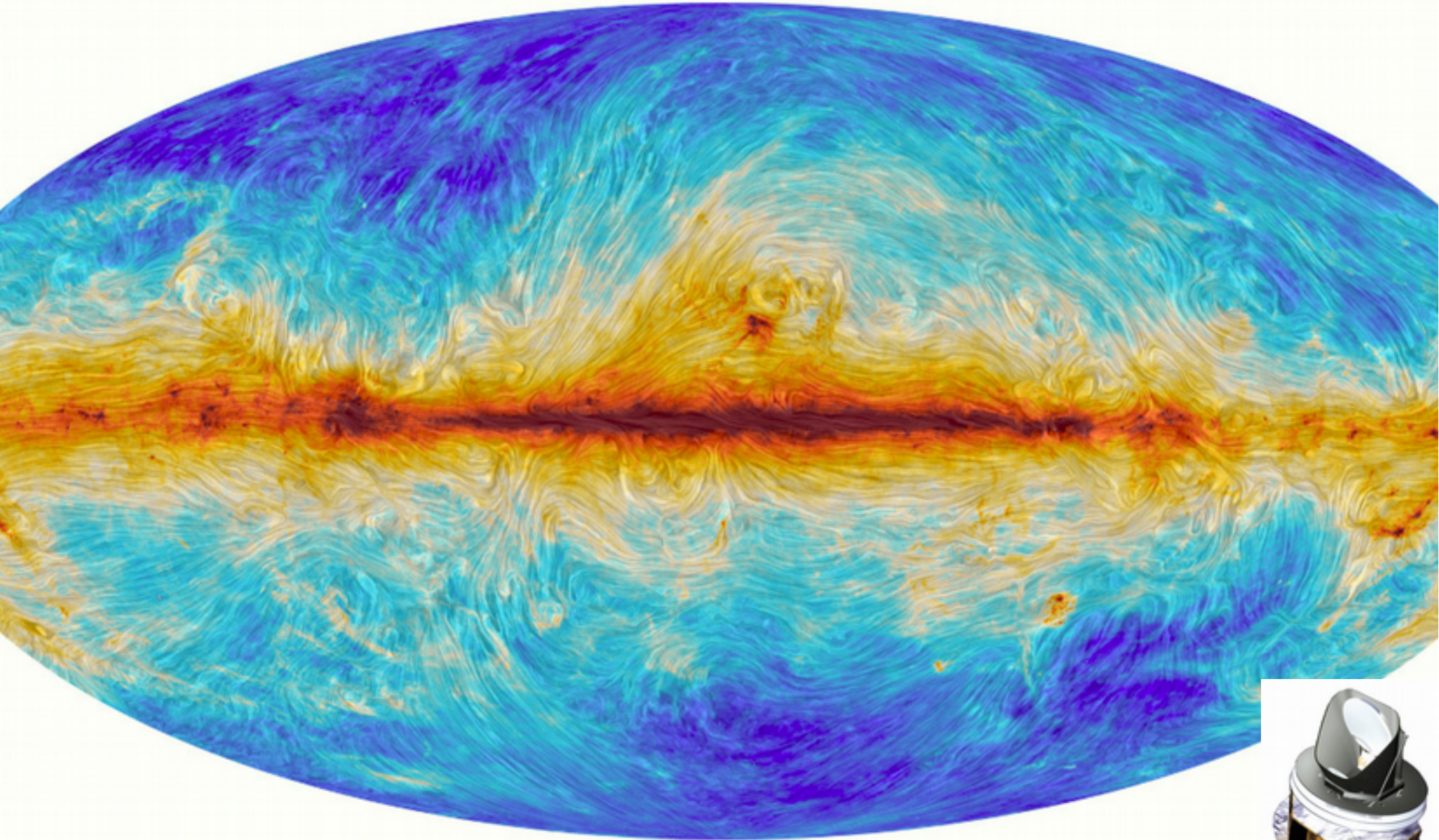
Magnetism in our Galaxy





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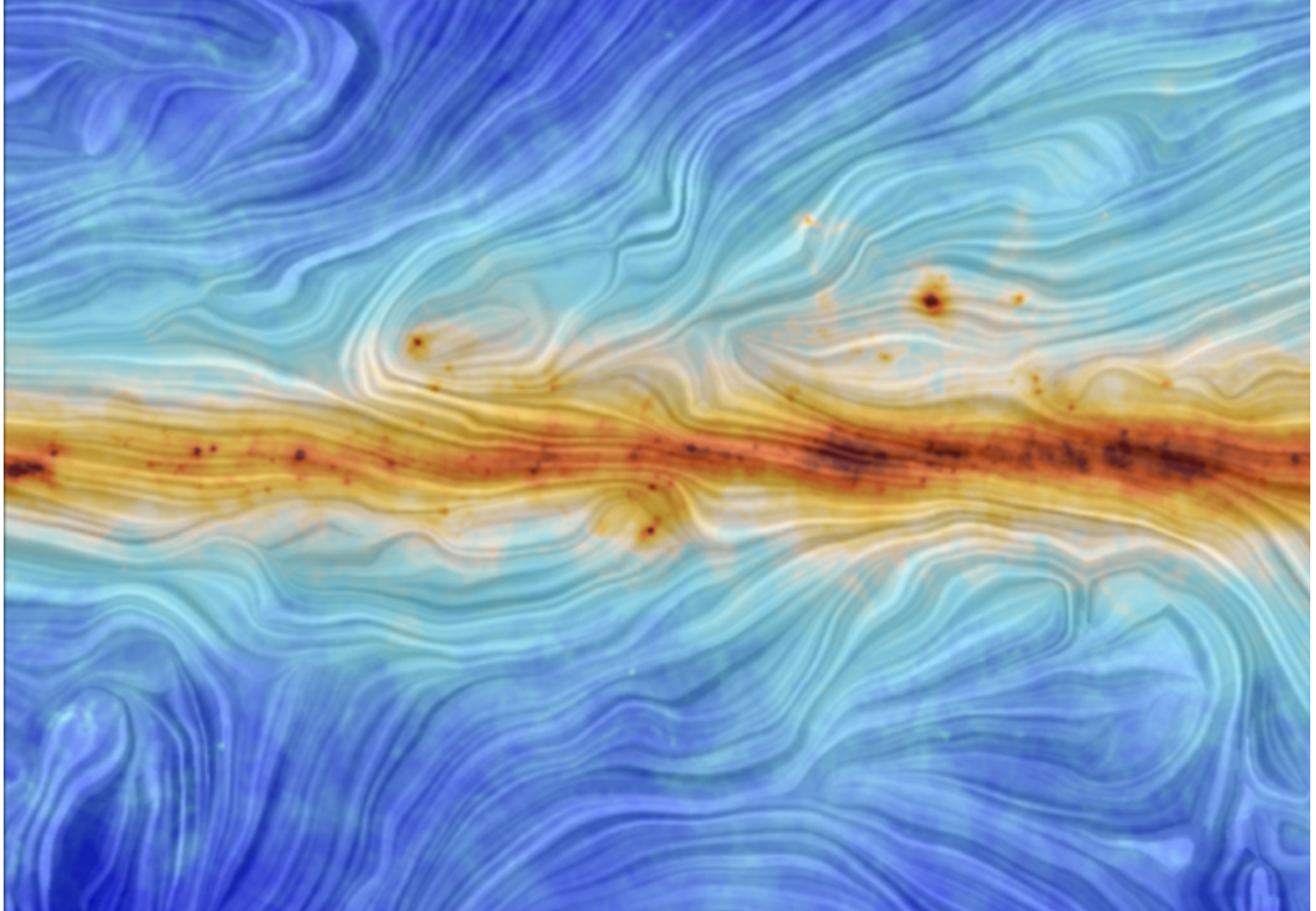
Magnetism in our Galaxy



Planck Satellite

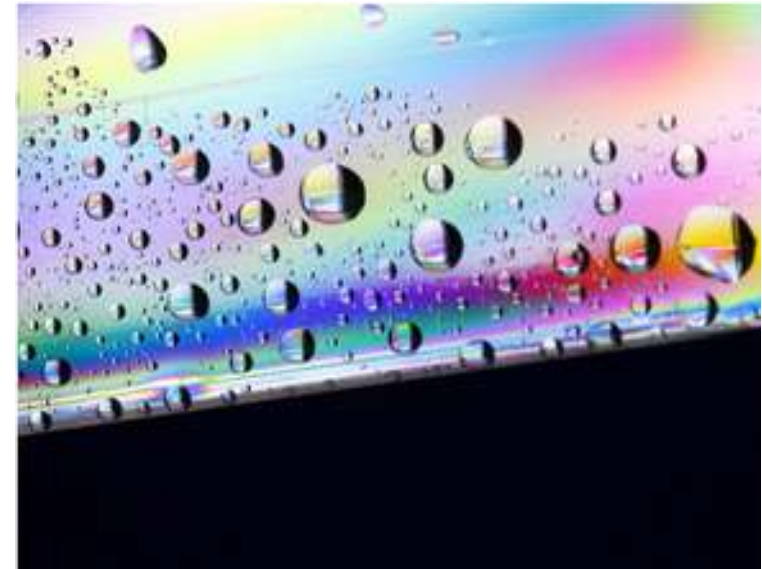
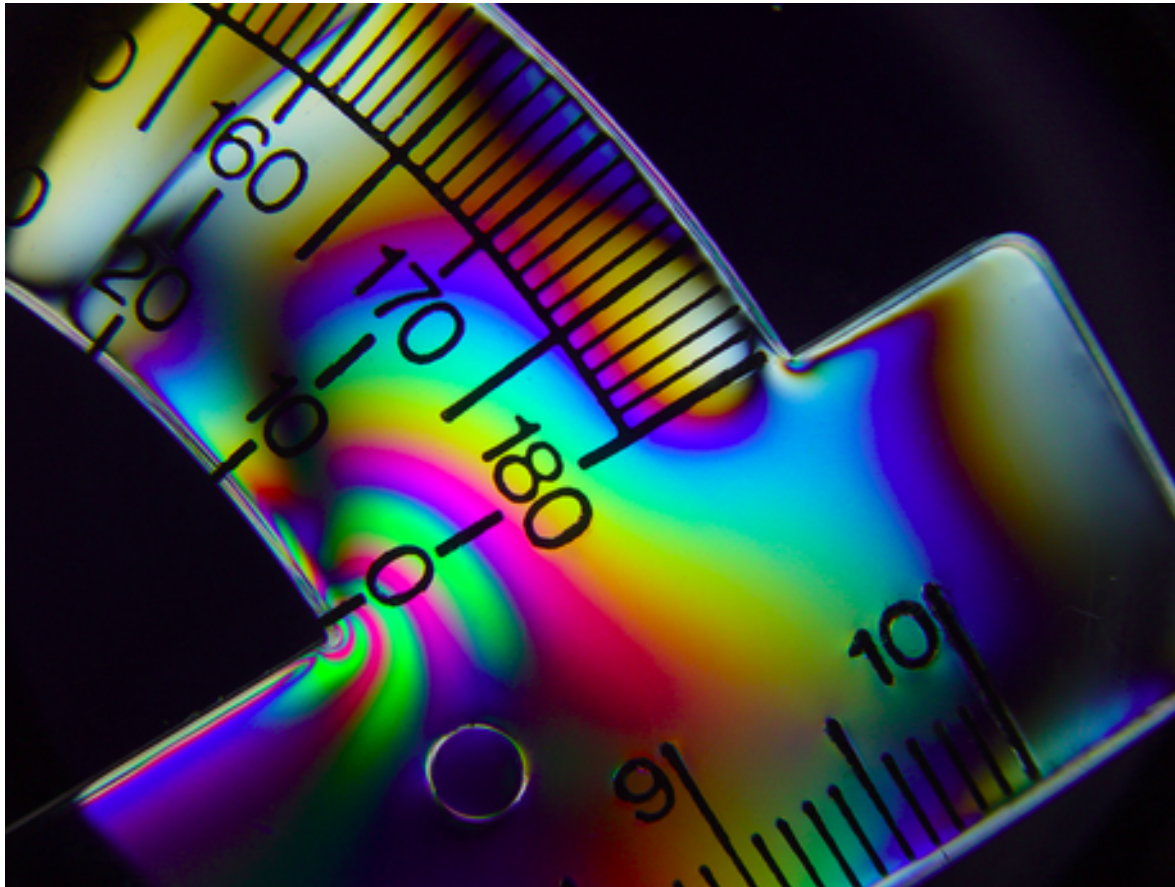


Magnetism in our Galaxy





Magnetism in our Galaxy



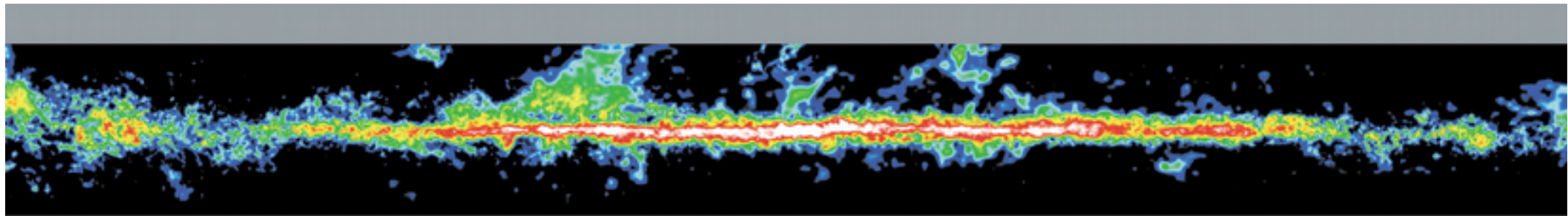


Magnetism in our Galaxy

Problem: we can't see very far using visible light.



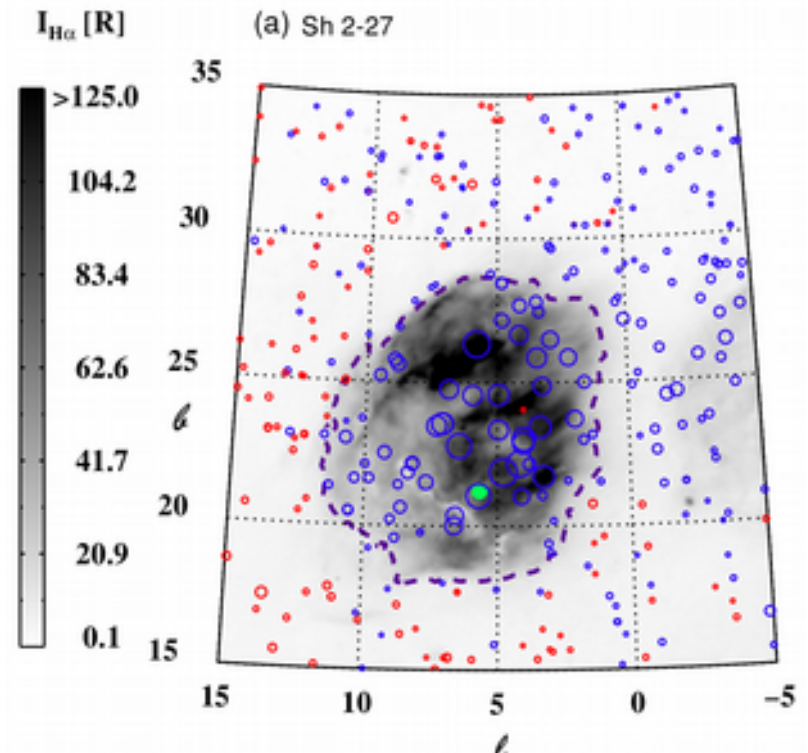
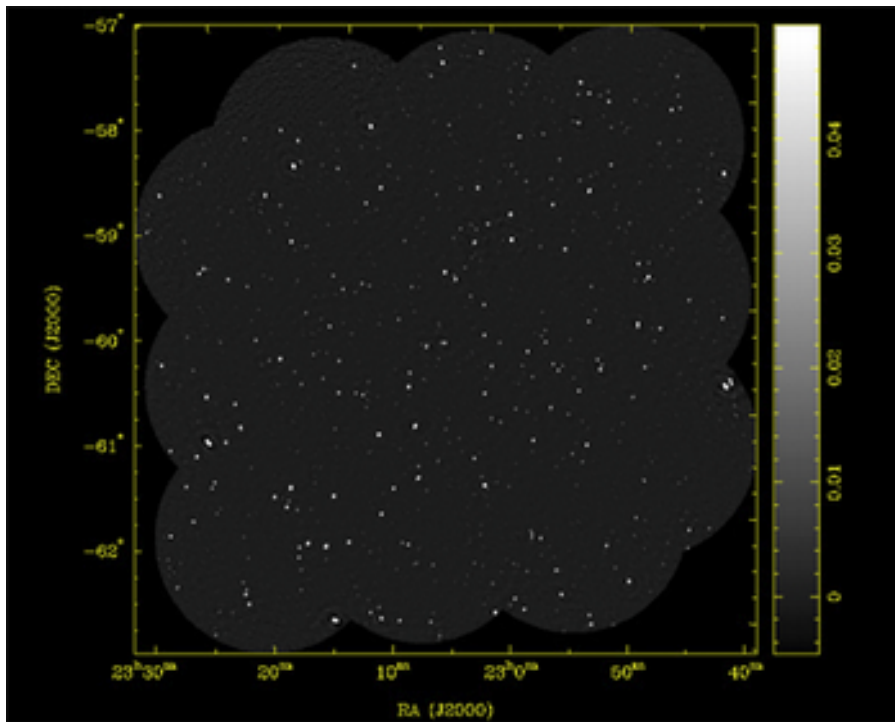
Solution: look at radio wavelengths and cut through the dust!





Magnetism in our Galaxy

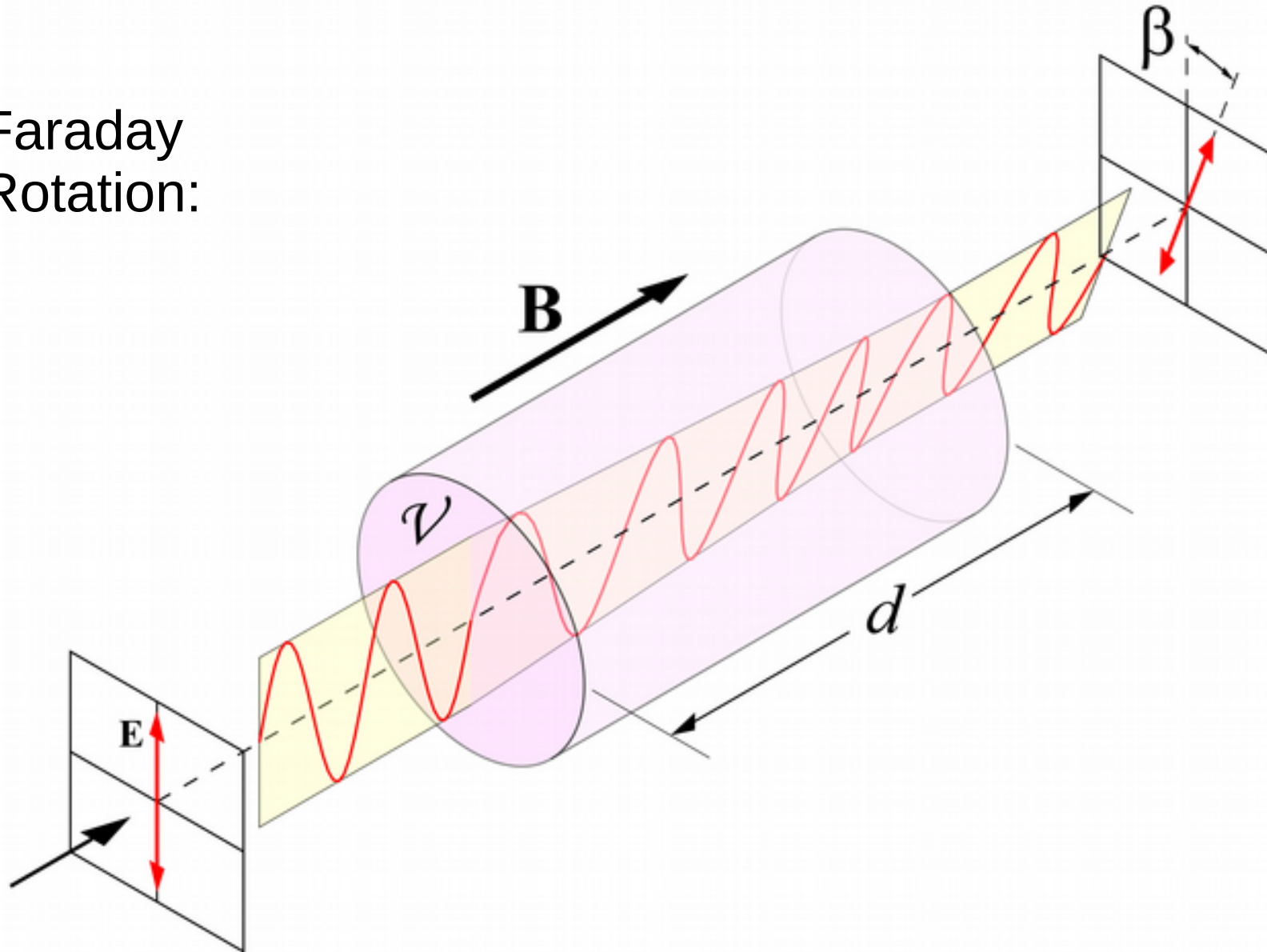
Polarised
Radio Waves





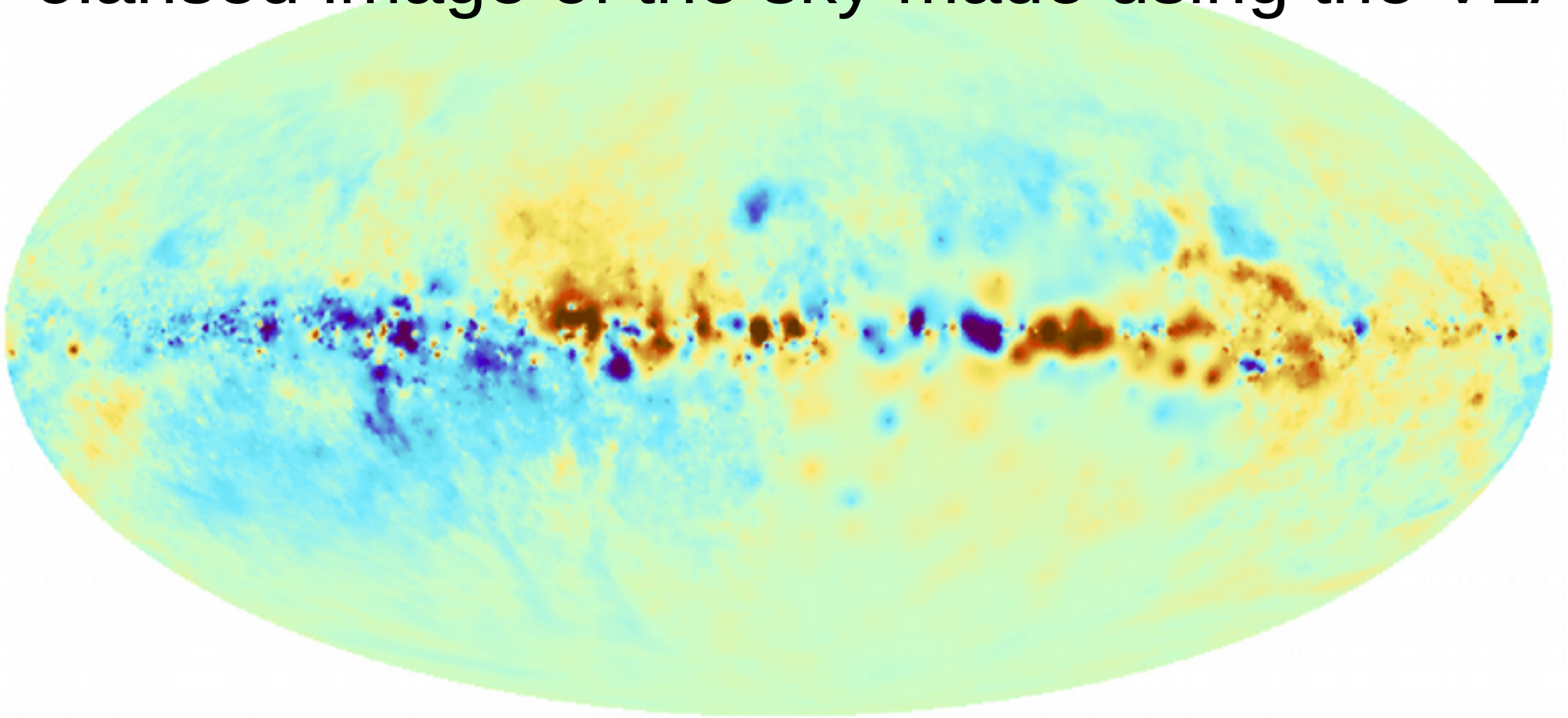
Magnetism in our Galaxy

Faraday
Rotation:





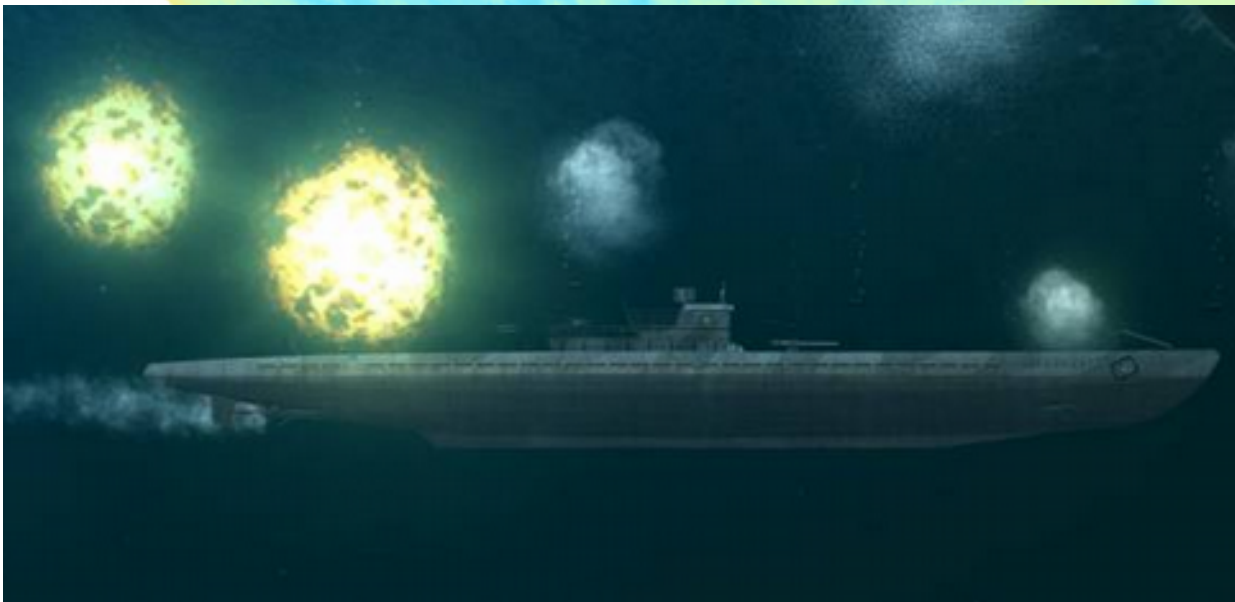
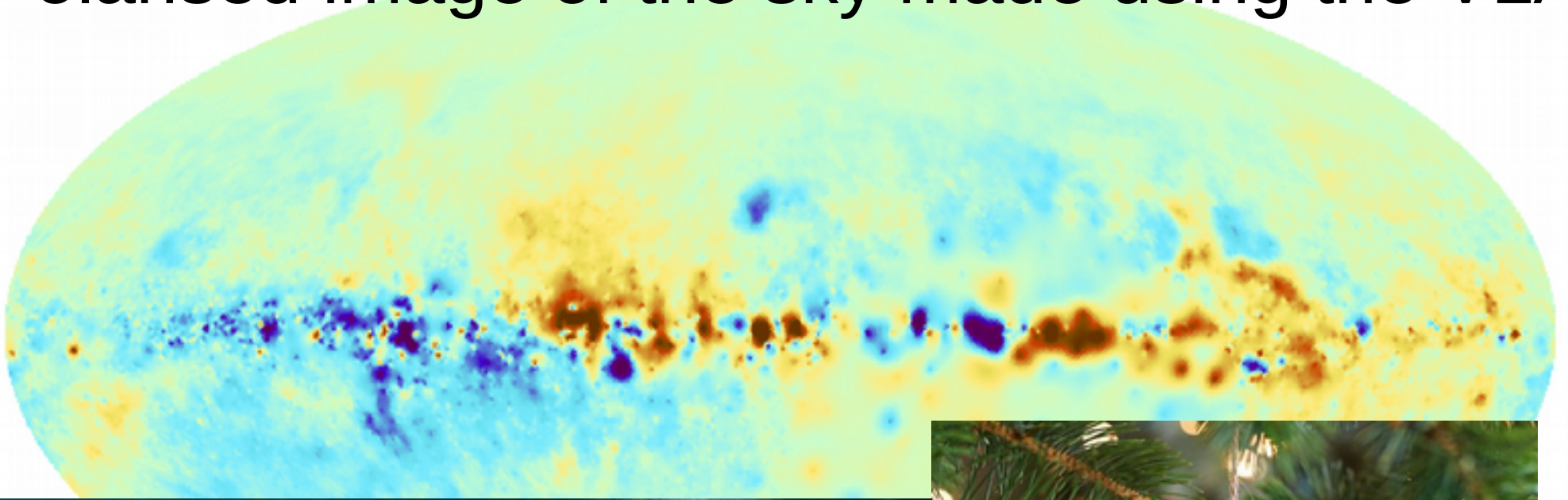
Polarised image of the sky made using the VLA





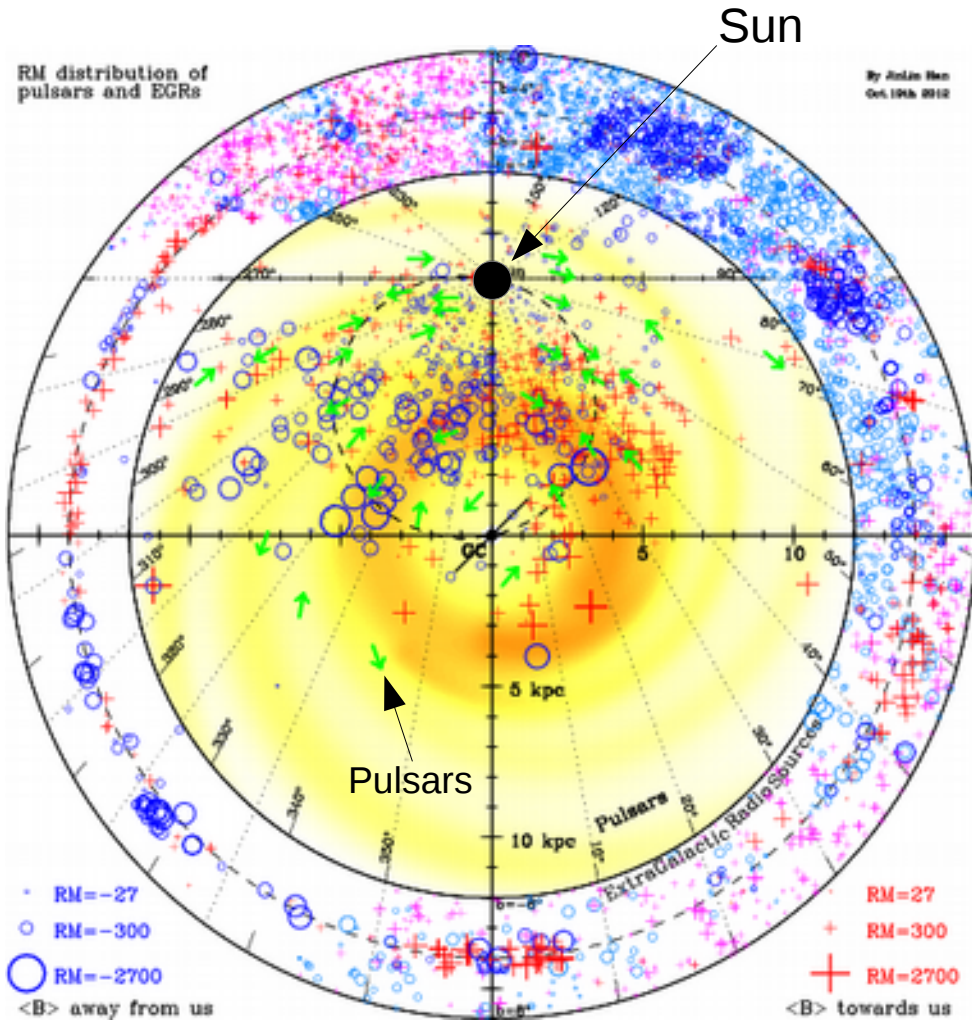
Magnetism in our Galaxy

Polarised image of the sky made using the VLA

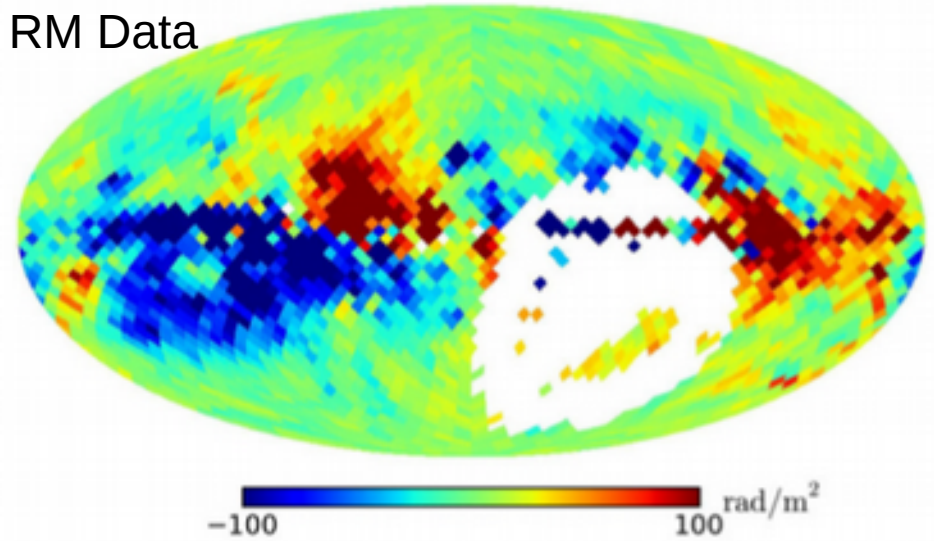




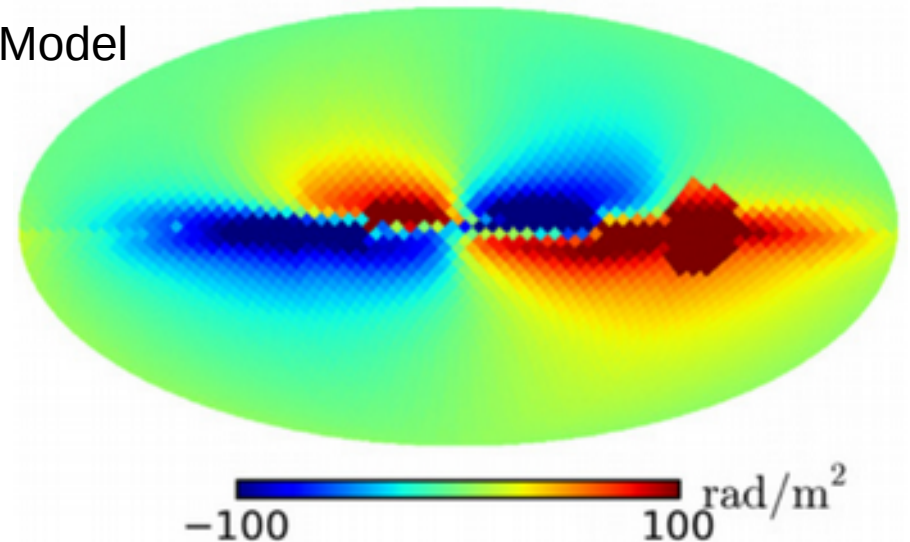
Magnetism in our Galaxy



RM Data

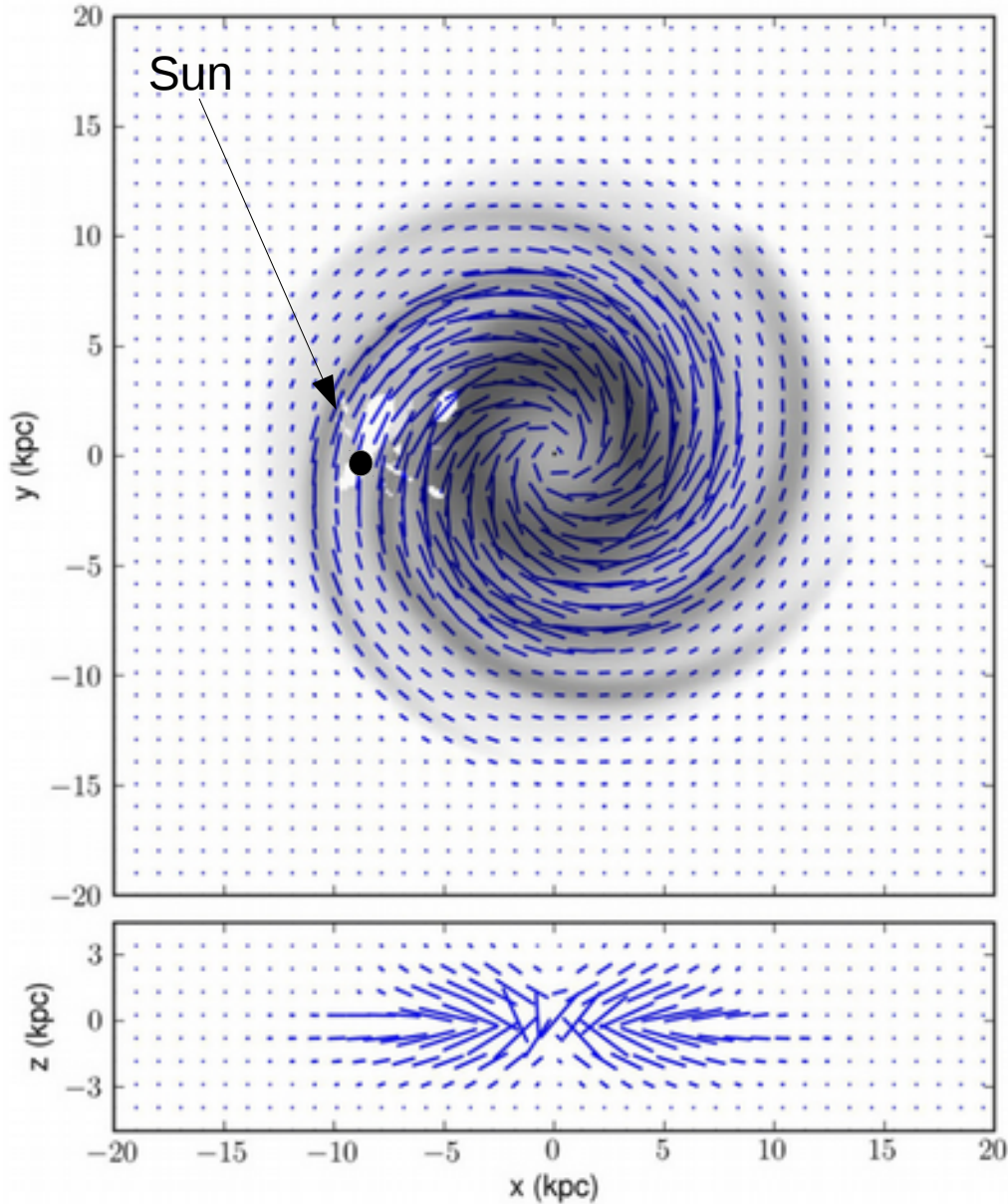


Model

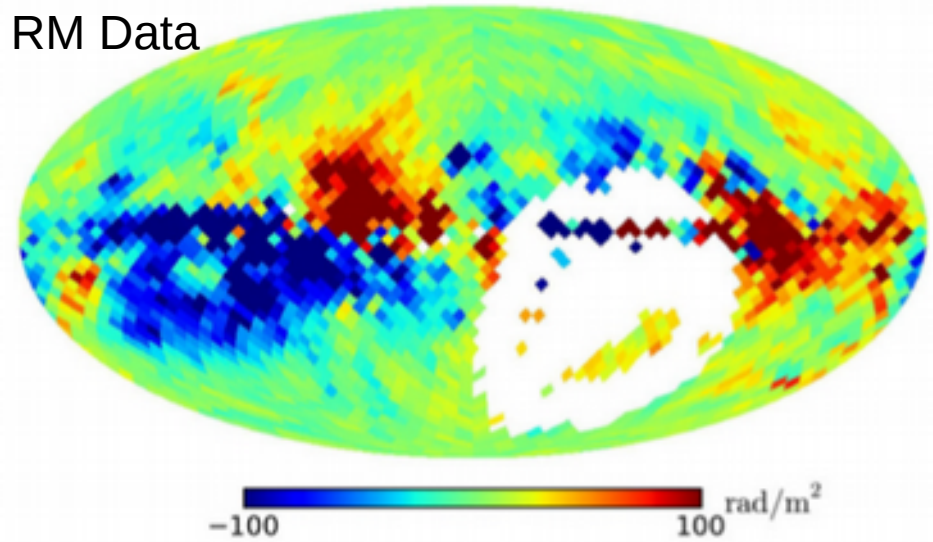




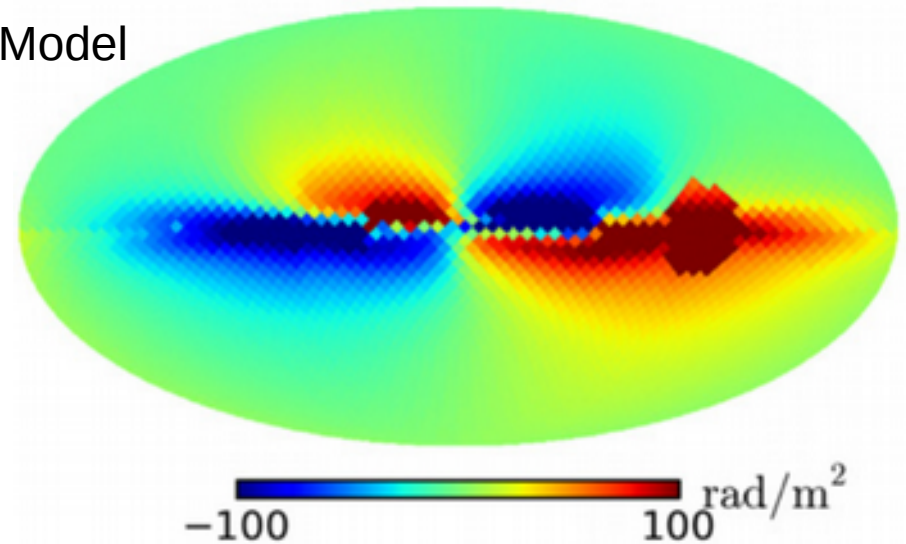
Magnetism in our Galaxy



RM Data

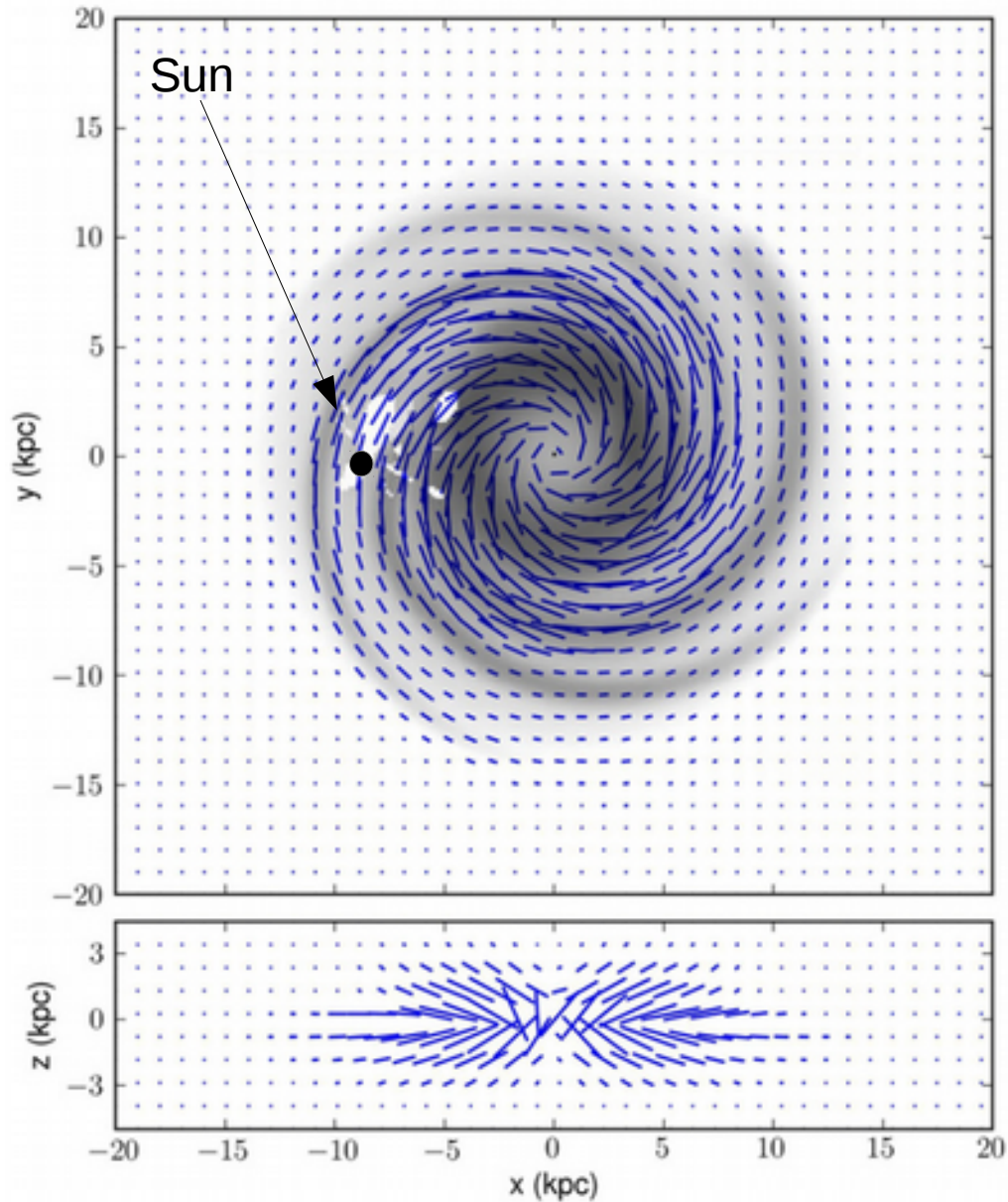


Model



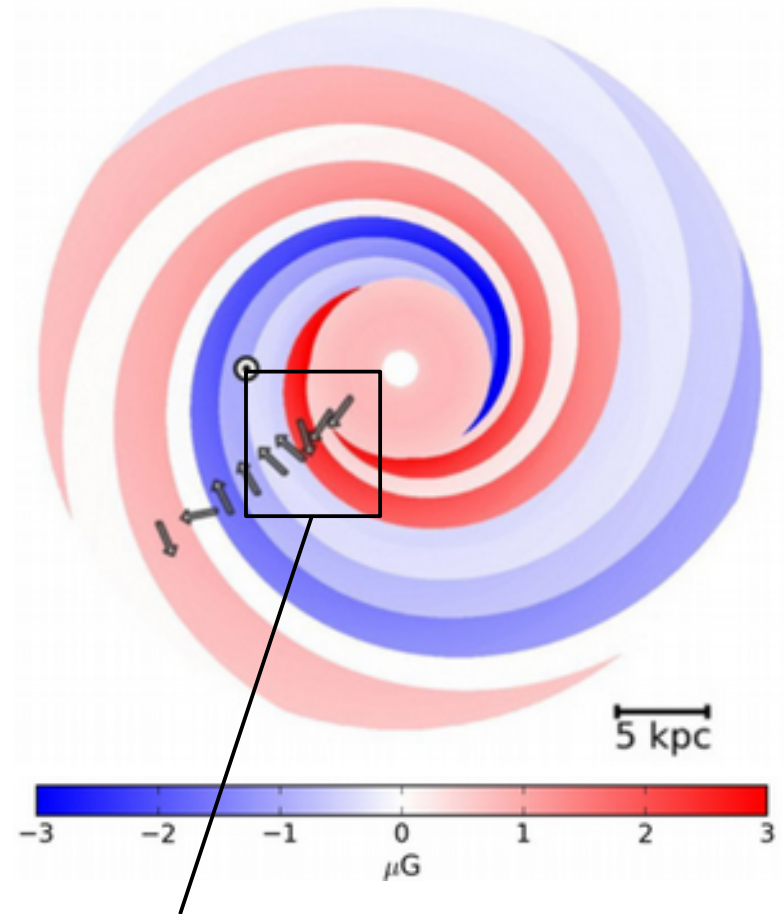
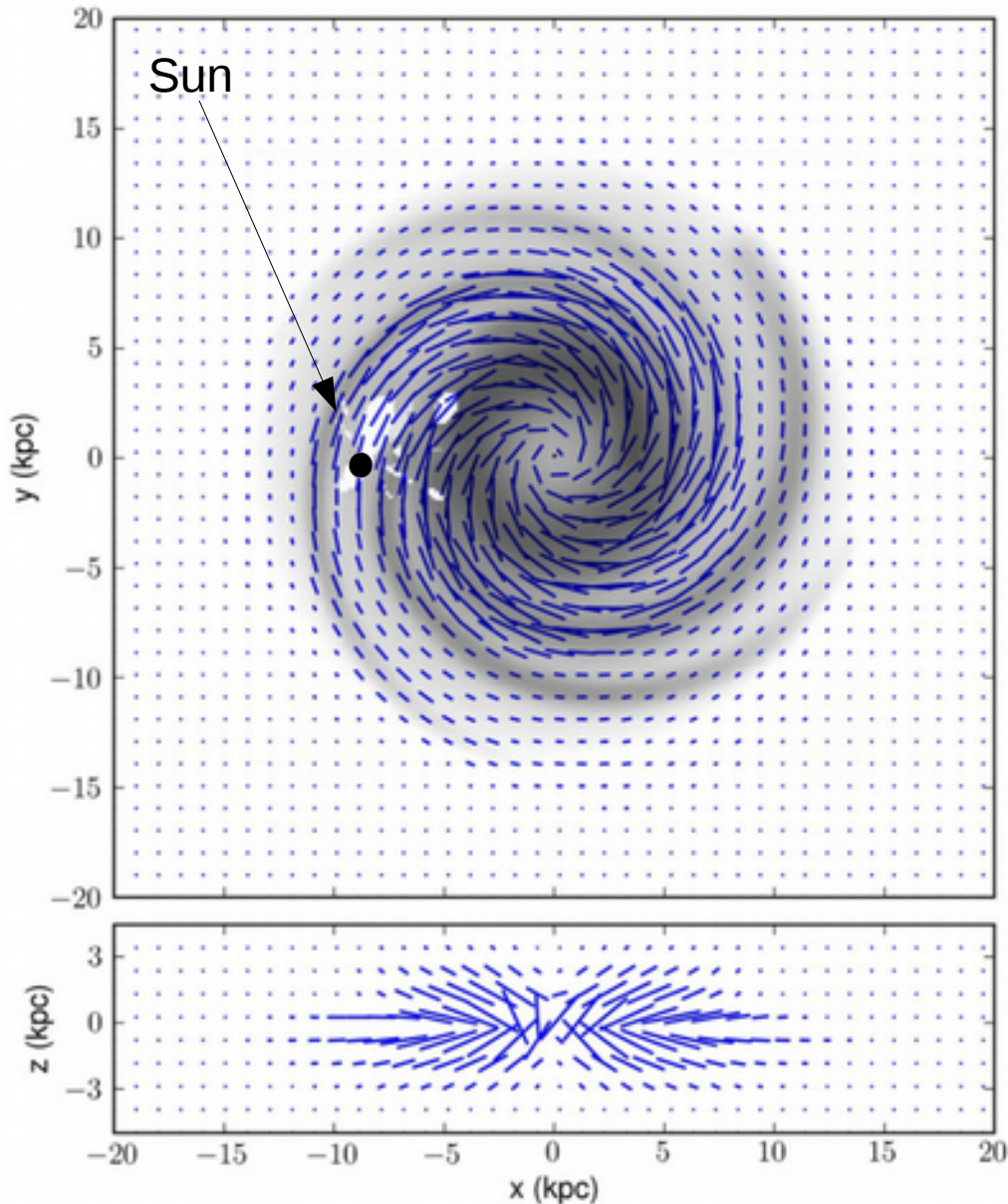


Magnetism in our Galaxy





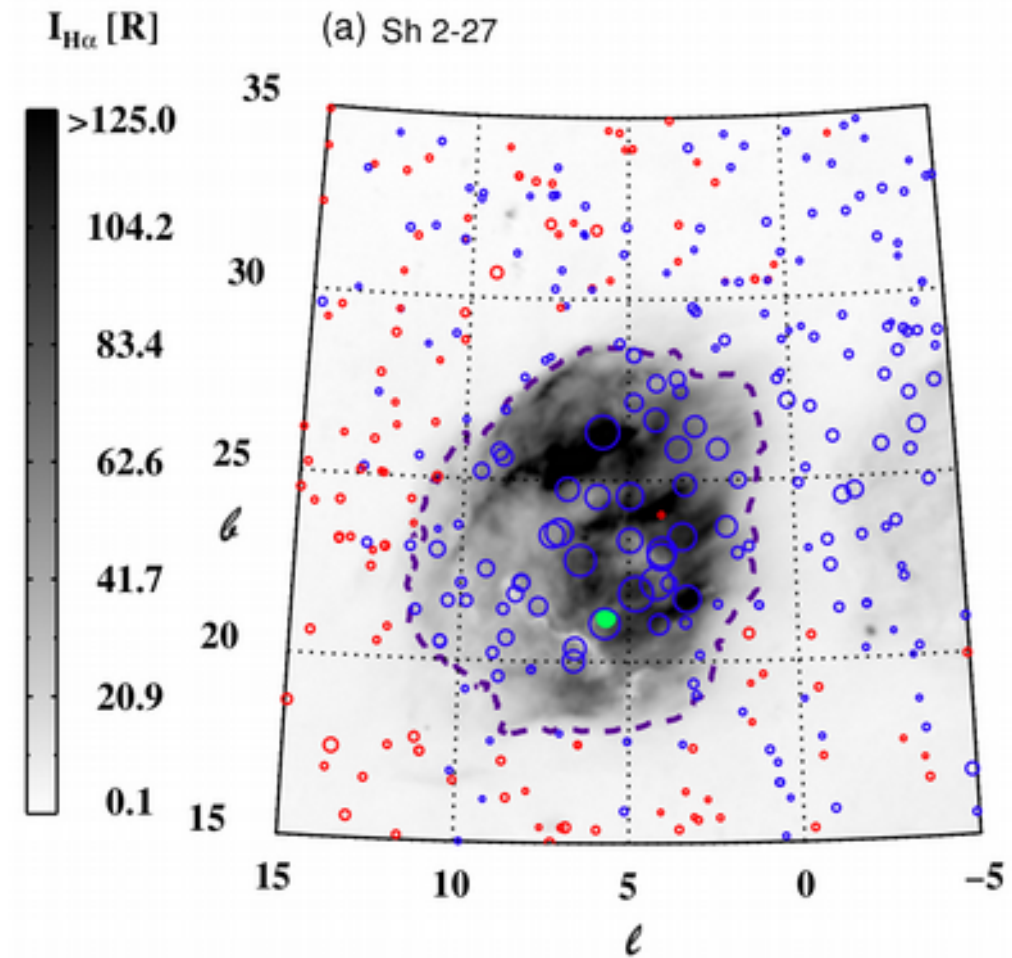
Magnetism in our Galaxy



Evidence for field reversals between arms
Not seen in external galaxies – are these real?



Magnetism in our Galaxy





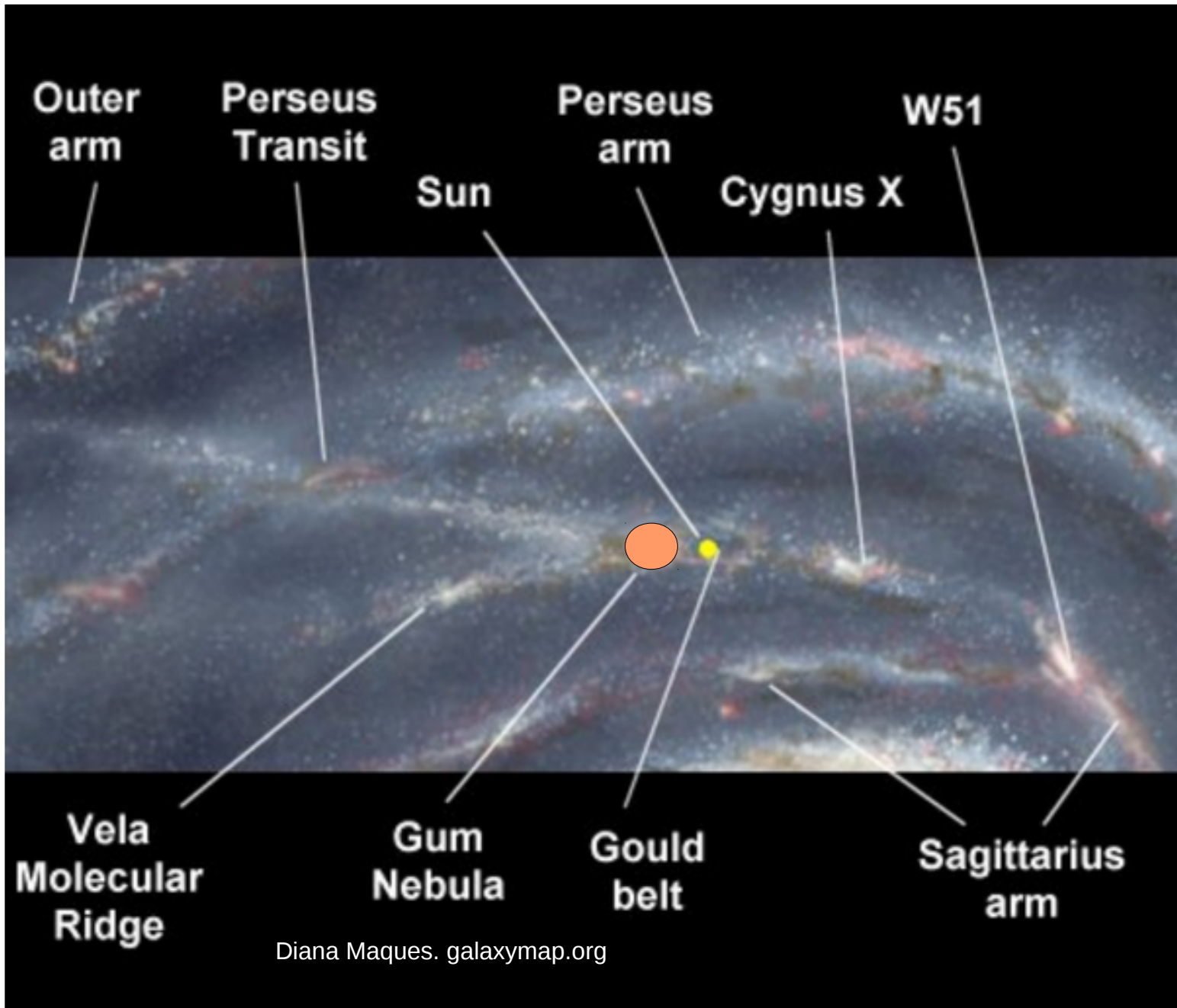
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Magnetism in our Galaxy





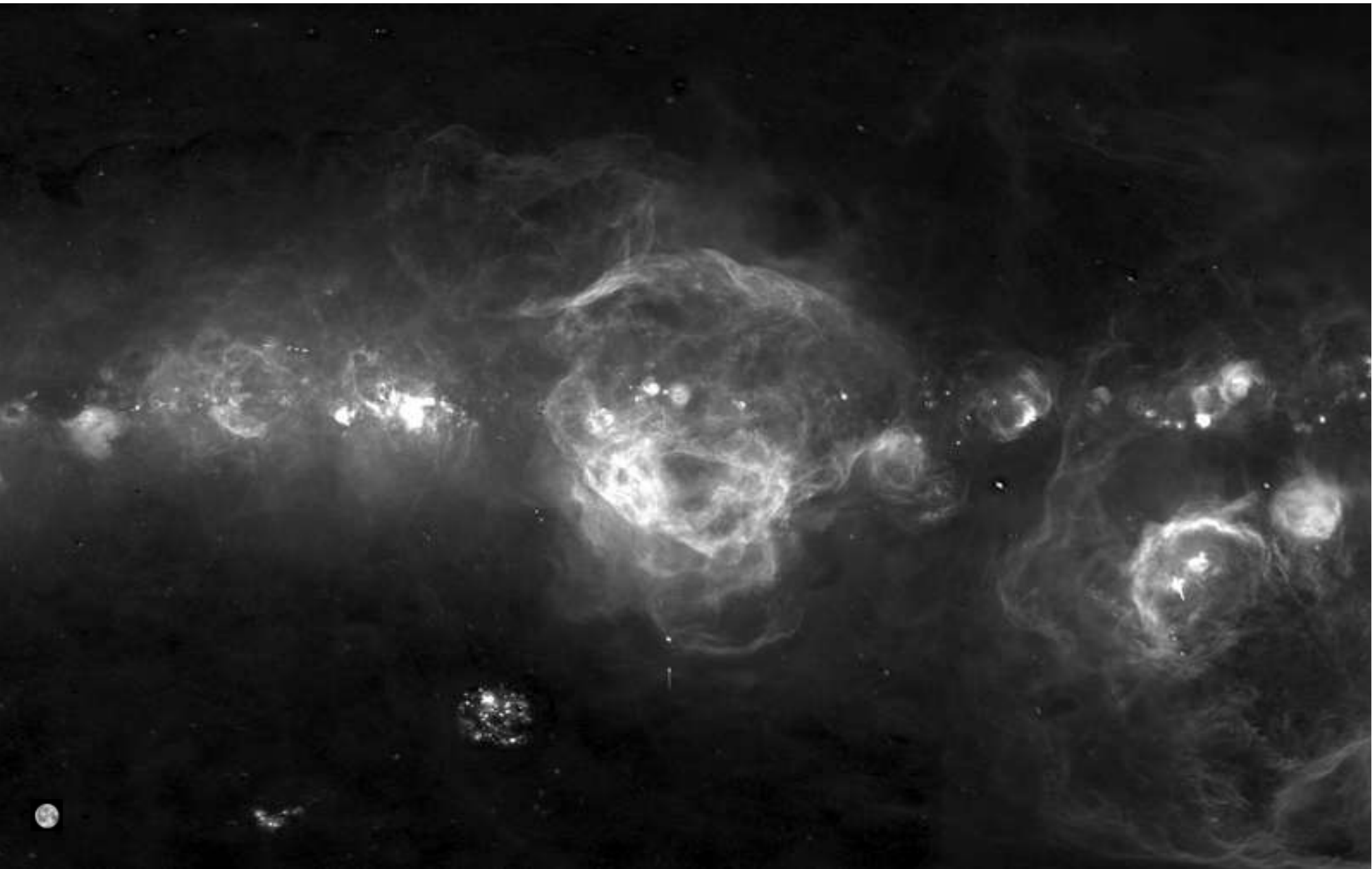
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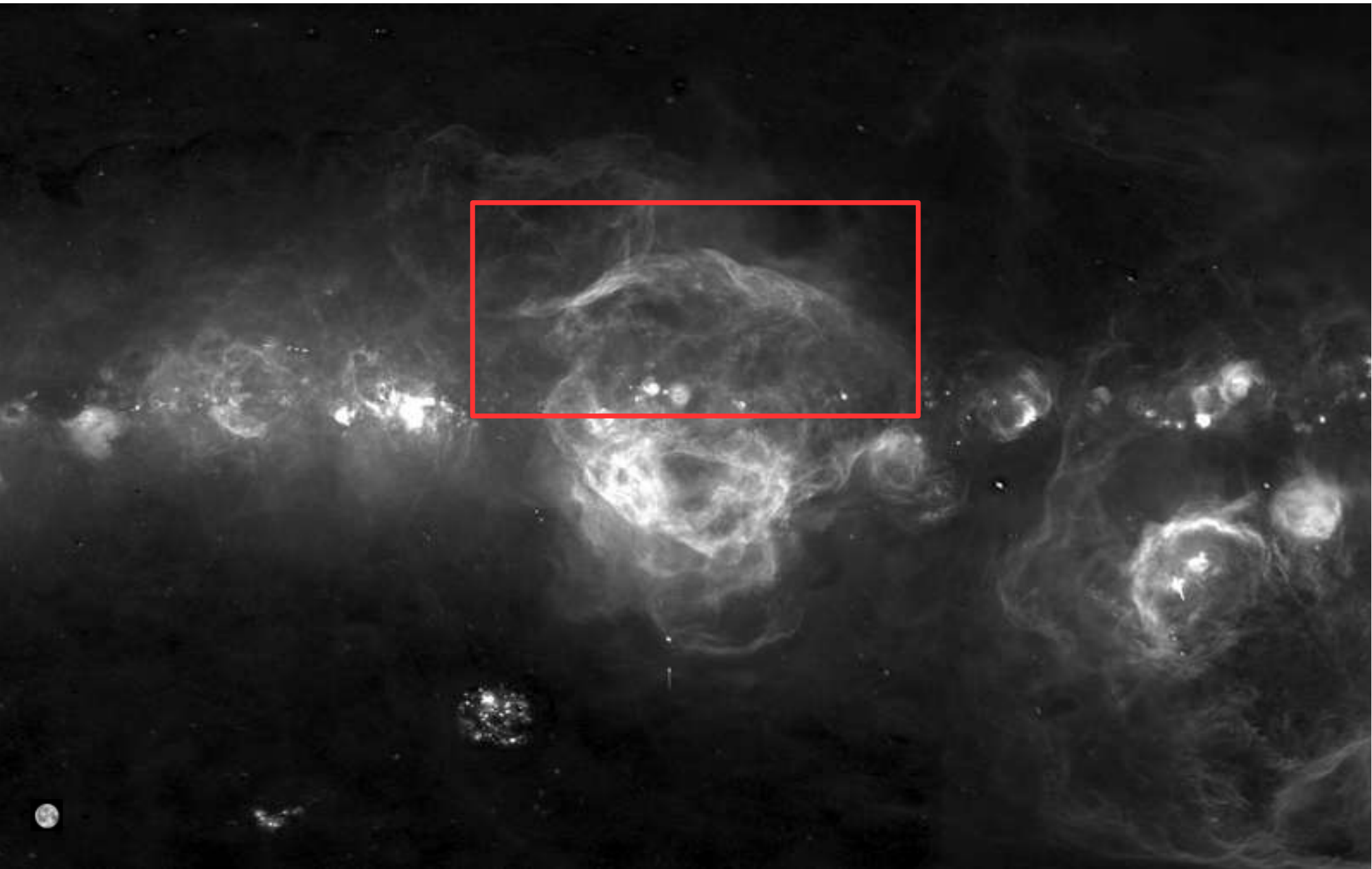
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Magnetism in our Galaxy



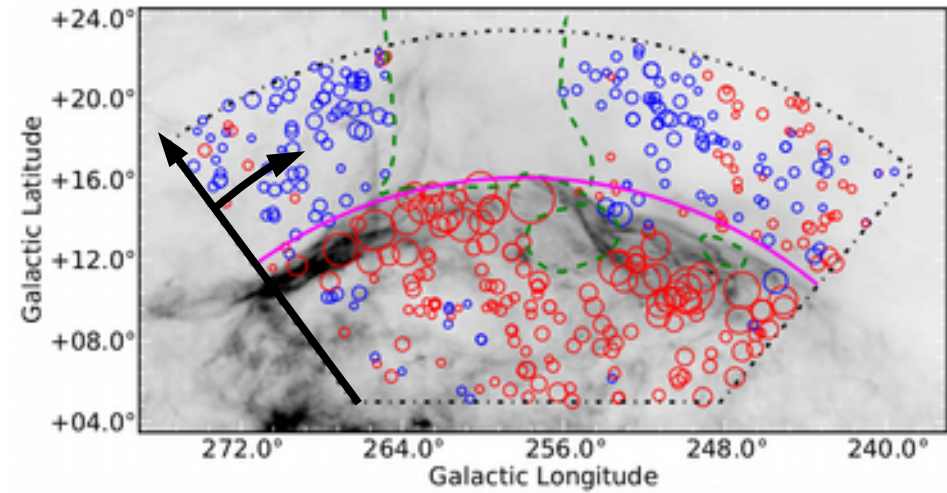


Magnetism in our Galaxy



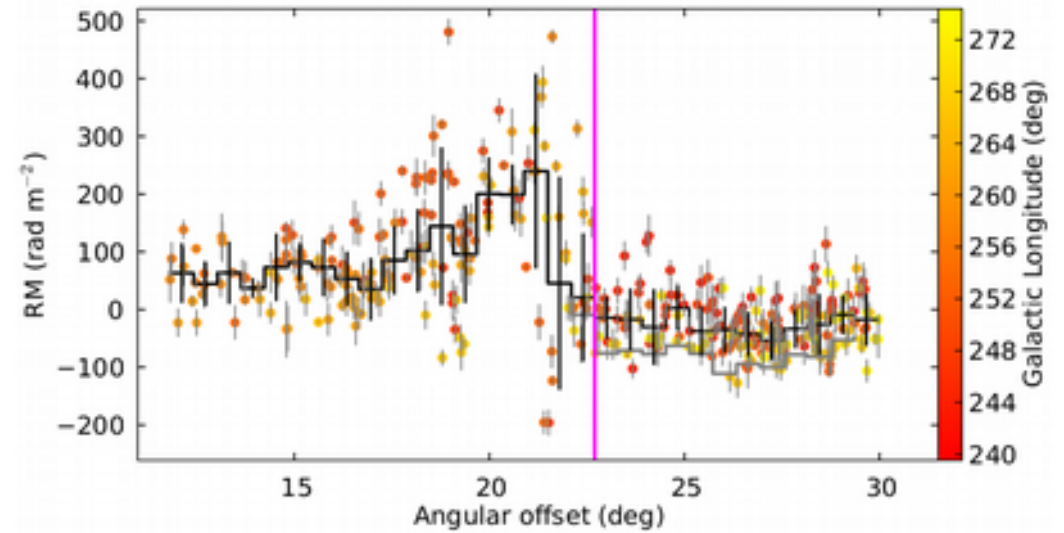
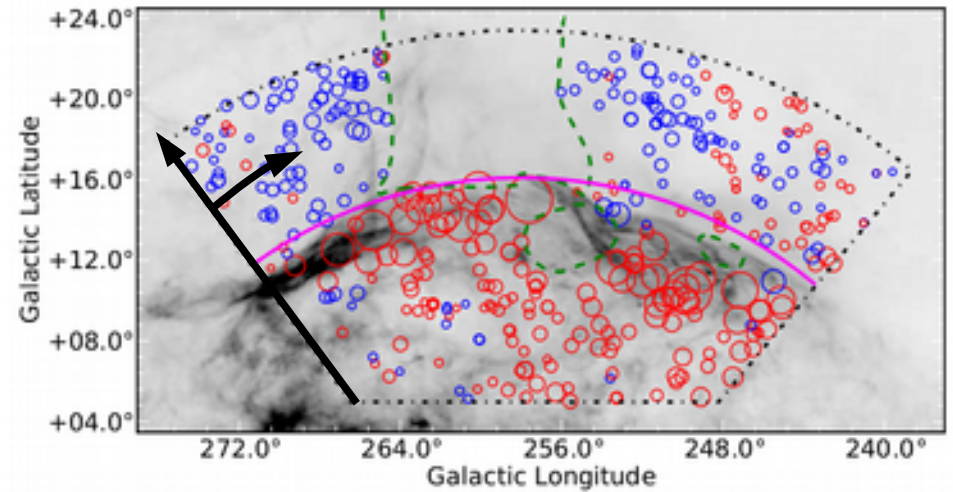


Magnetism in our Galaxy



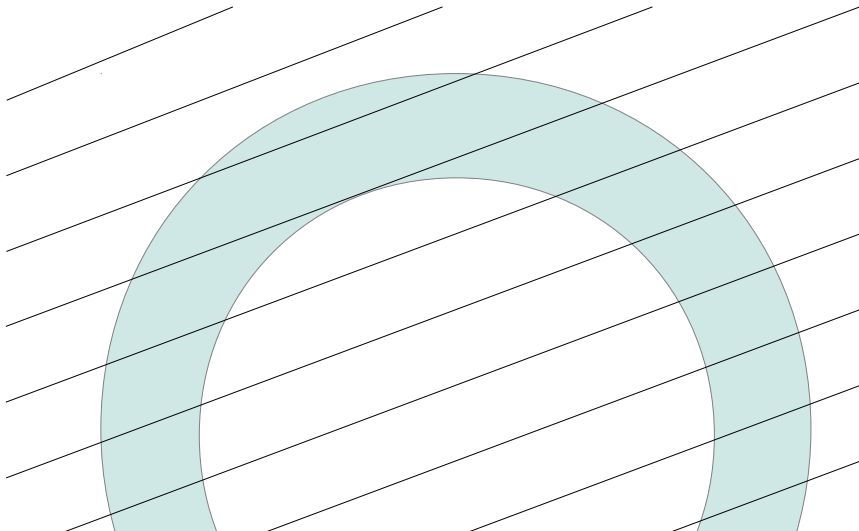
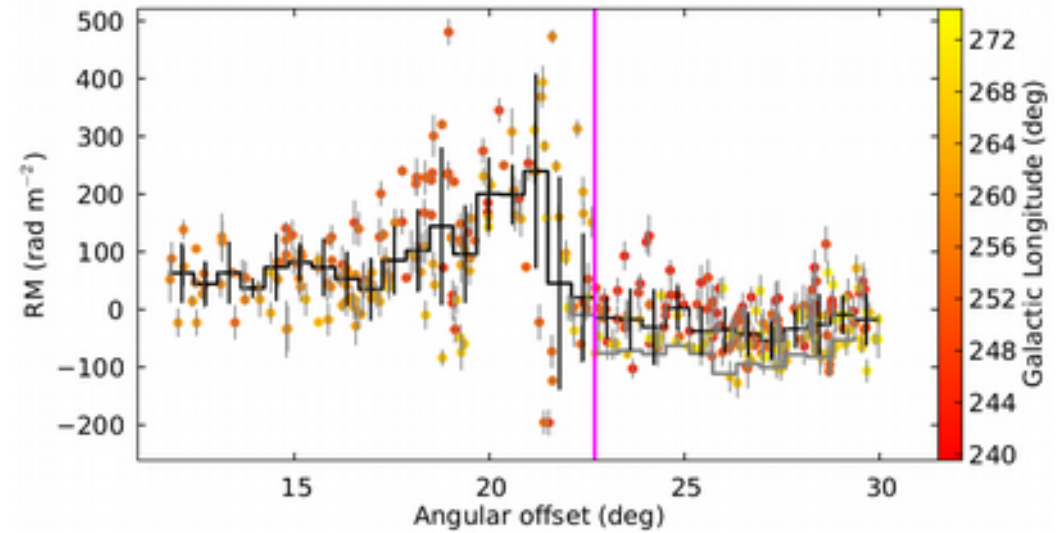
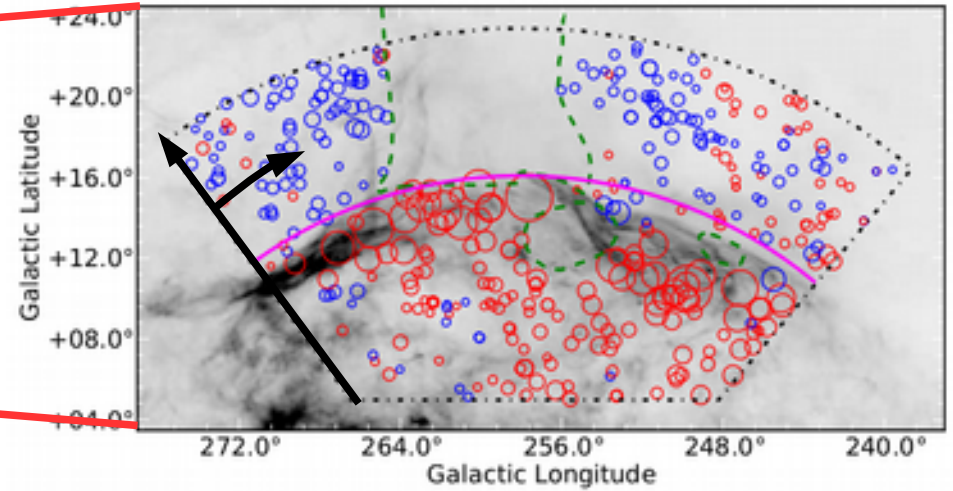
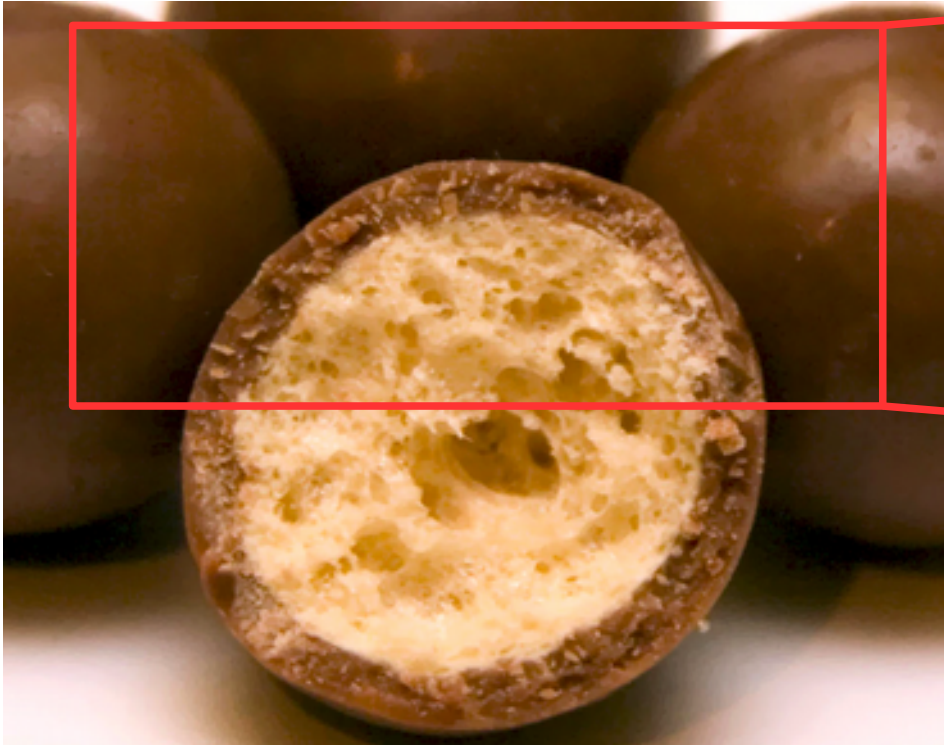


Magnetism in our Galaxy





Magnetism in our Galaxy



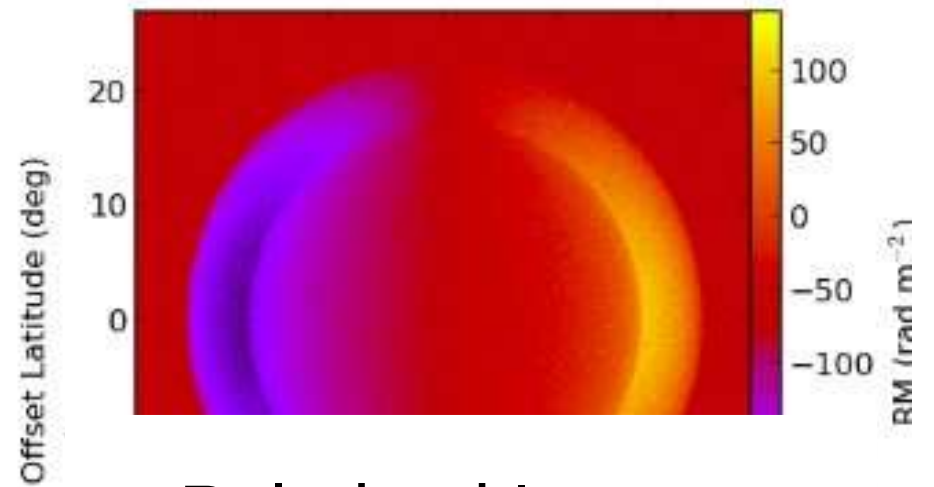


Magnetism in our Galaxy

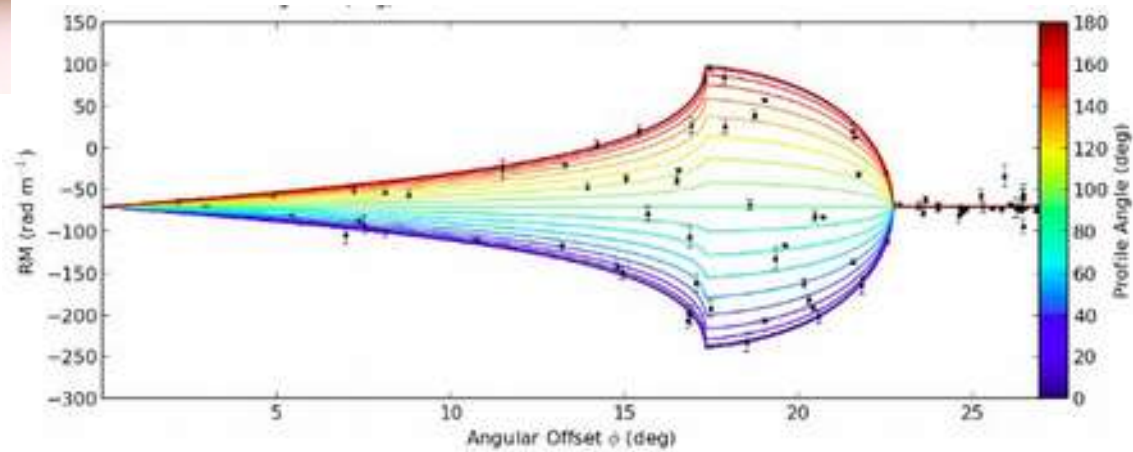


Magnetic field angle

$$\Theta = 0 \text{ degrees}$$



Polarised Image



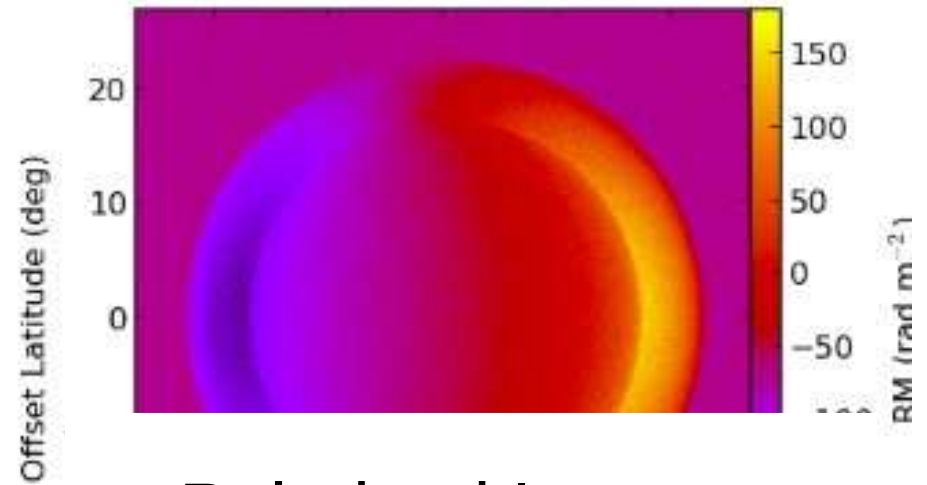


Magnetism in our Galaxy

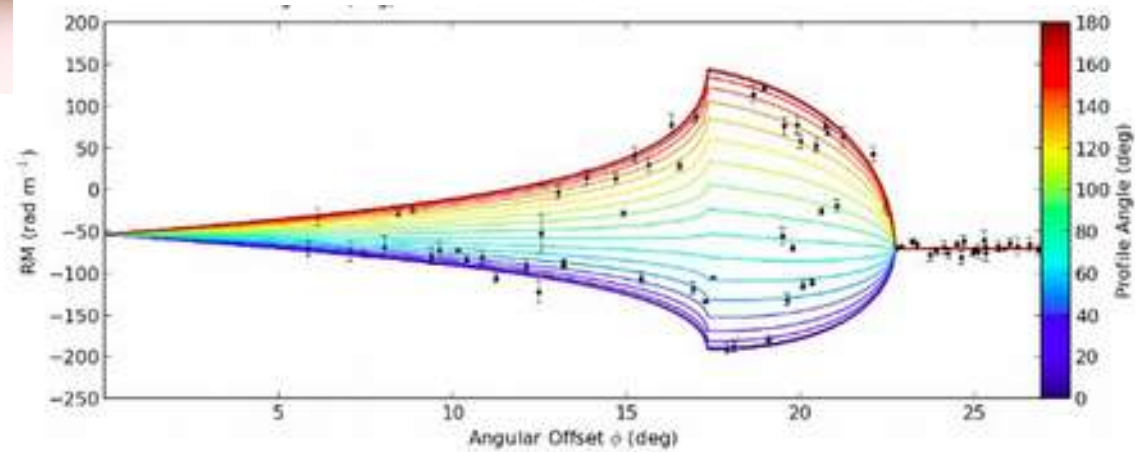


Magnetic field angle

$$\Theta = 5 \text{ degrees}$$



Polarised Image



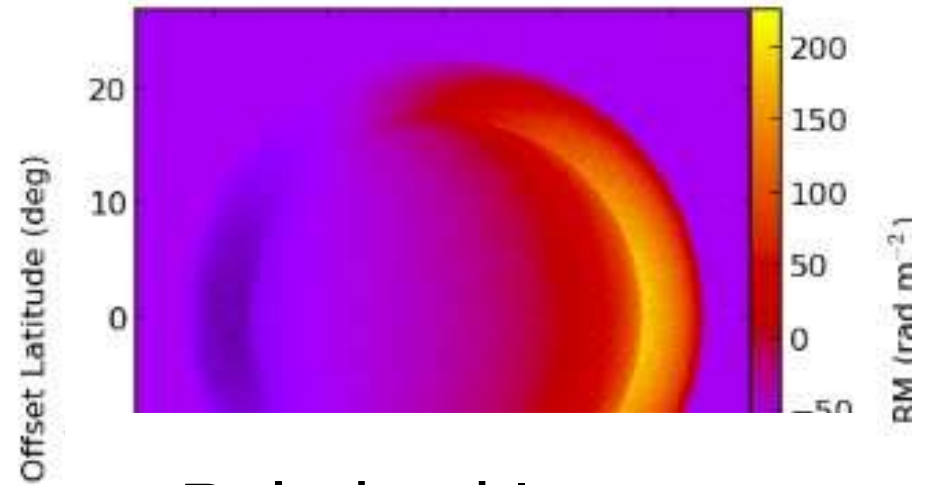


Magnetism in our Galaxy

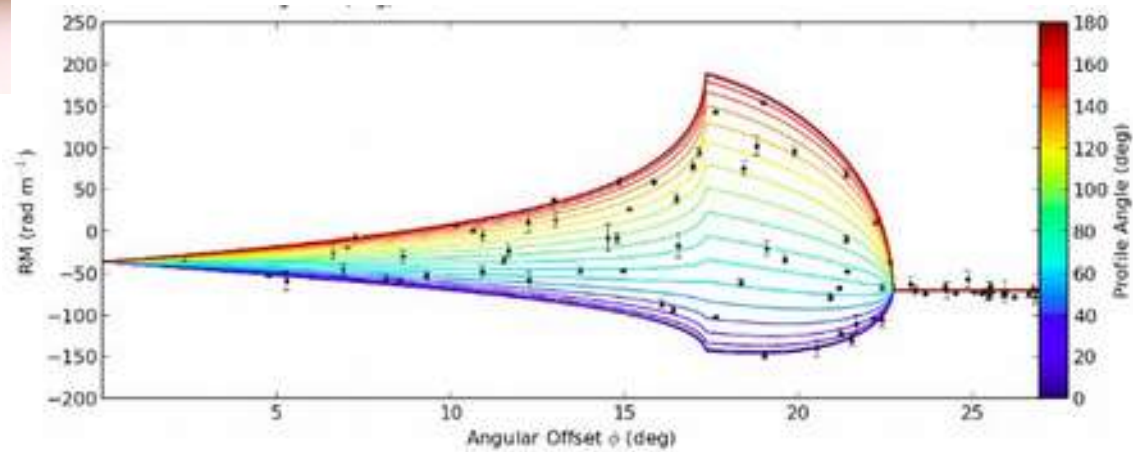


Magnetic field angle

$$\Theta = 15 \text{ degrees}$$



Polarised Image



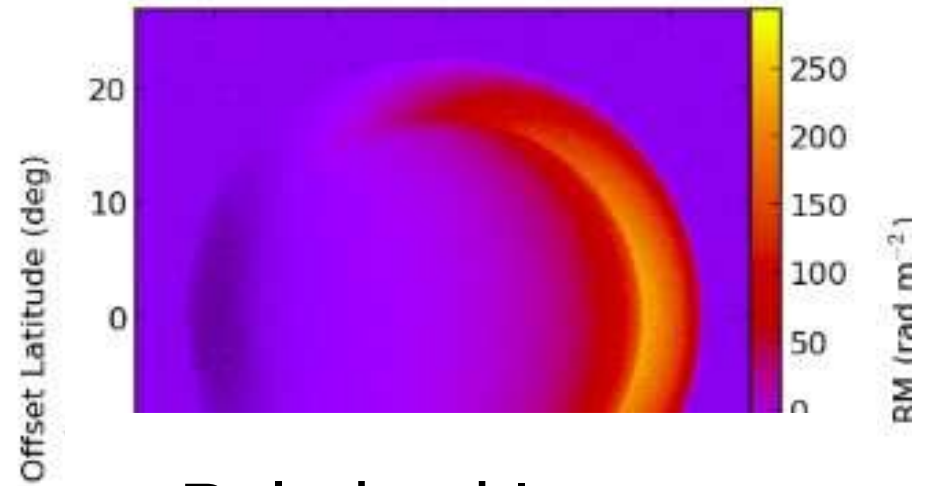


Magnetism in our Galaxy

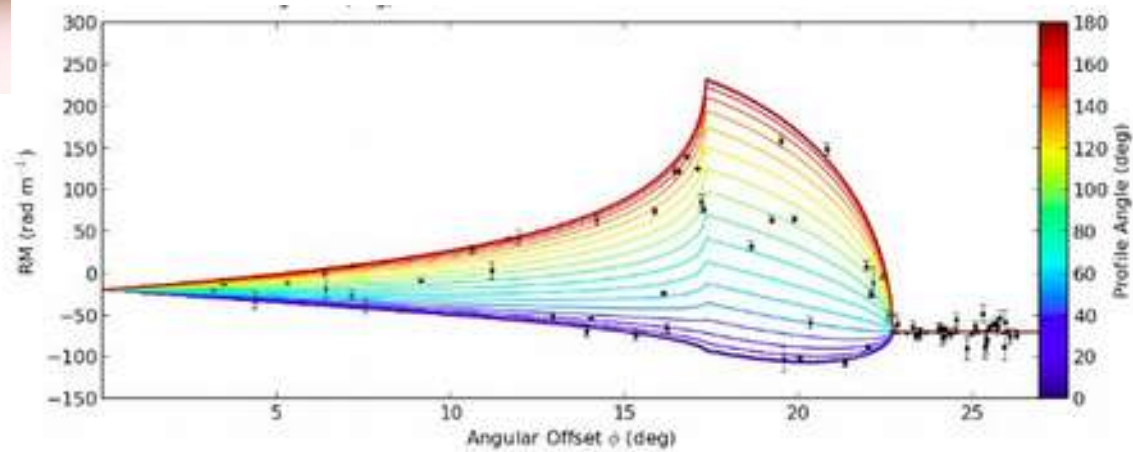


Magnetic field angle

$$\Theta = 20 \text{ degrees}$$



Polarised Image



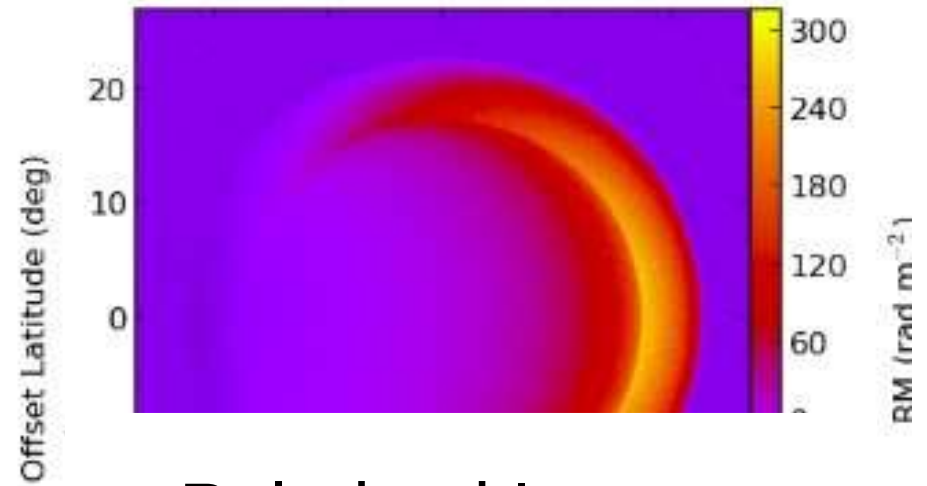


Magnetism in our Galaxy

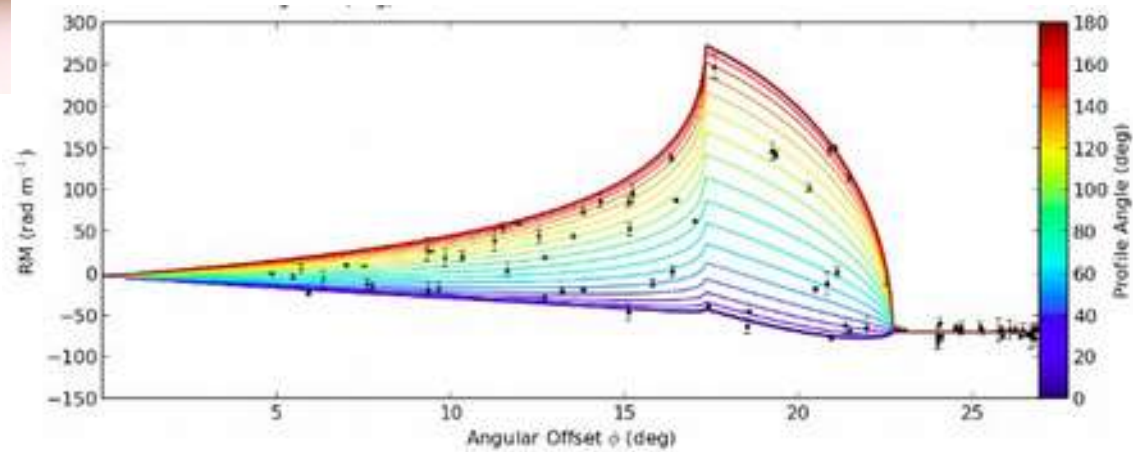


Magnetic field angle

$$\Theta = 50 \text{ degrees}$$



Polarised Image



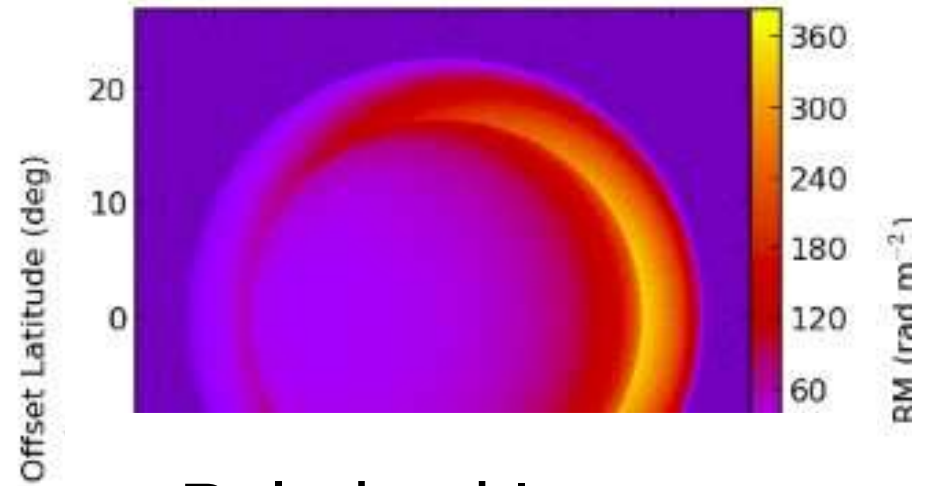


Magnetism in our Galaxy

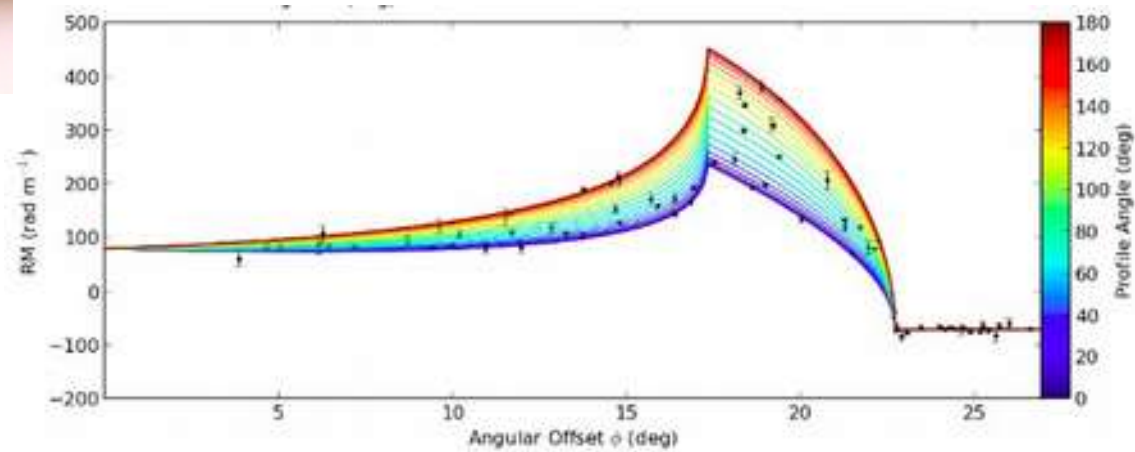


Magnetic field angle

$$\Theta = 80 \text{ degrees}$$



Polarised Image



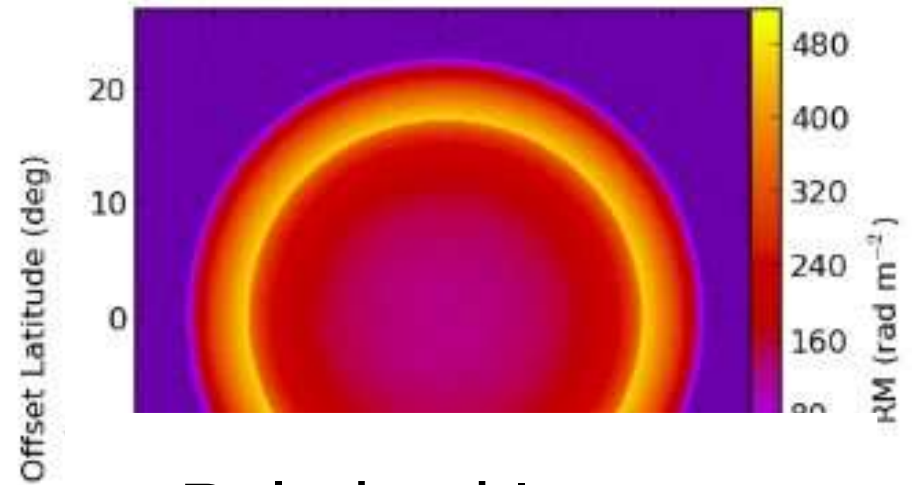


Magnetism in our Galaxy

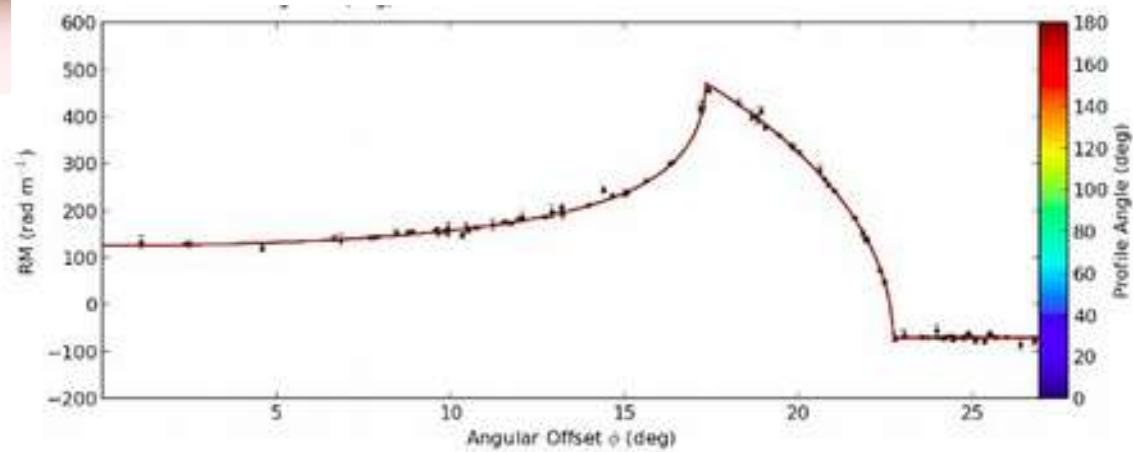


Magnetic field angle

$$\Theta = 90 \text{ degrees}$$

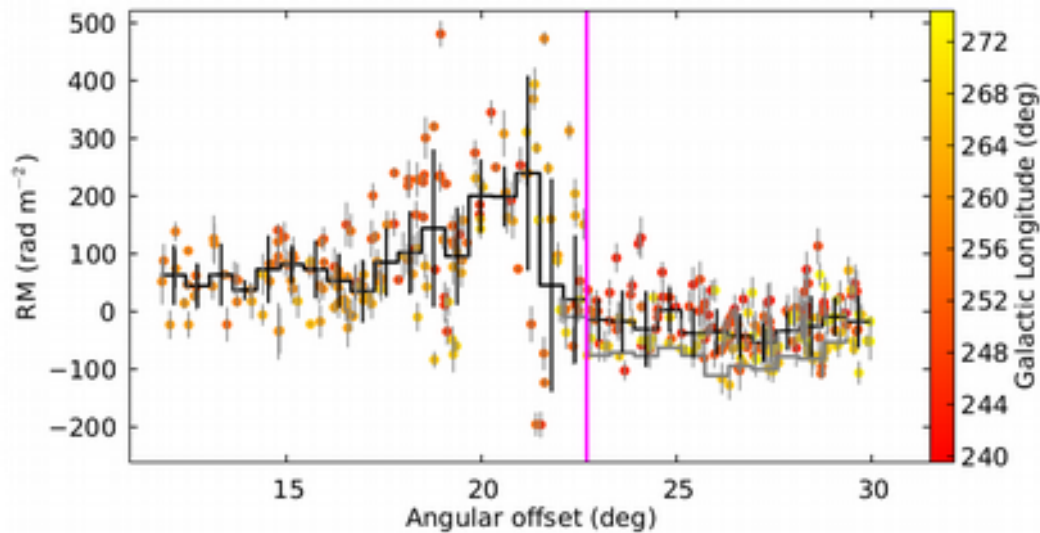
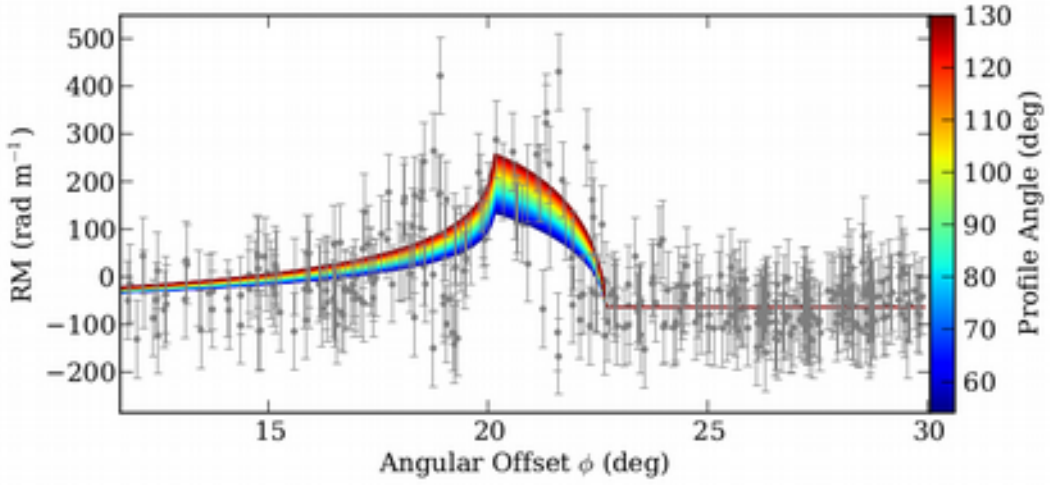
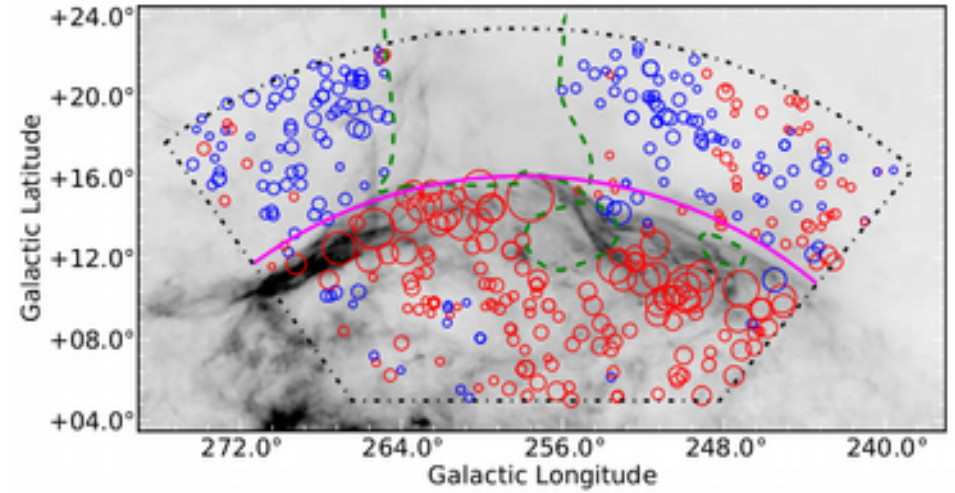
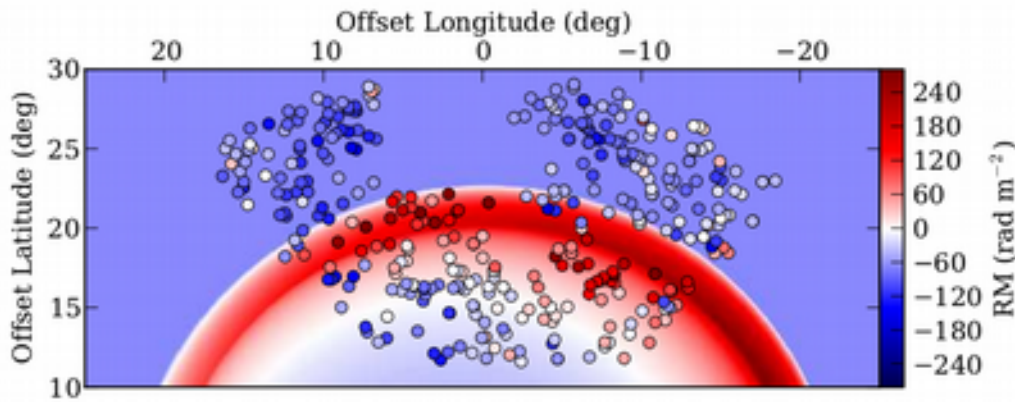


Polarised Image



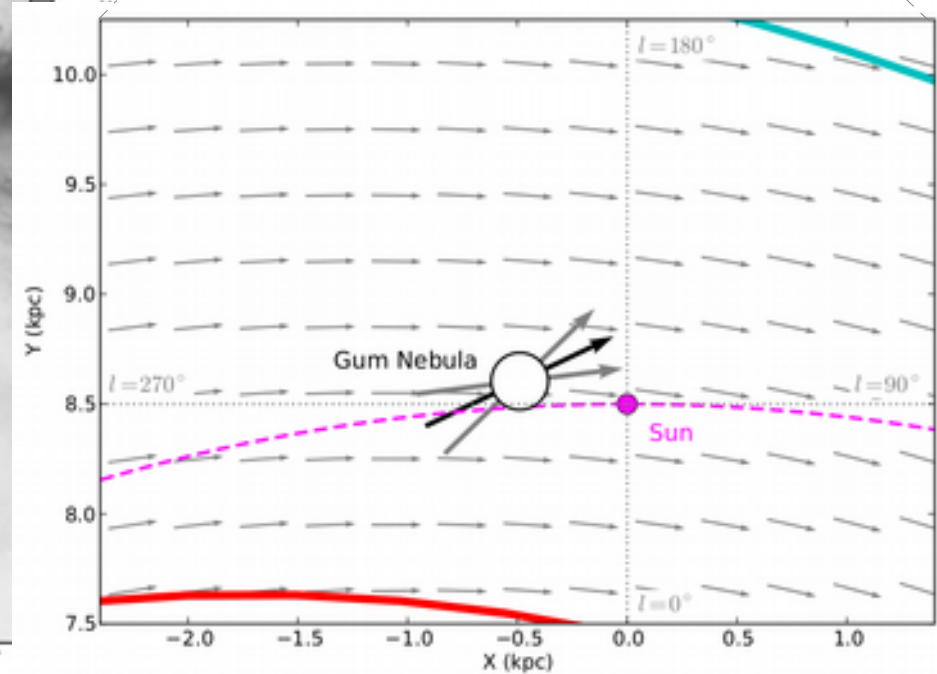
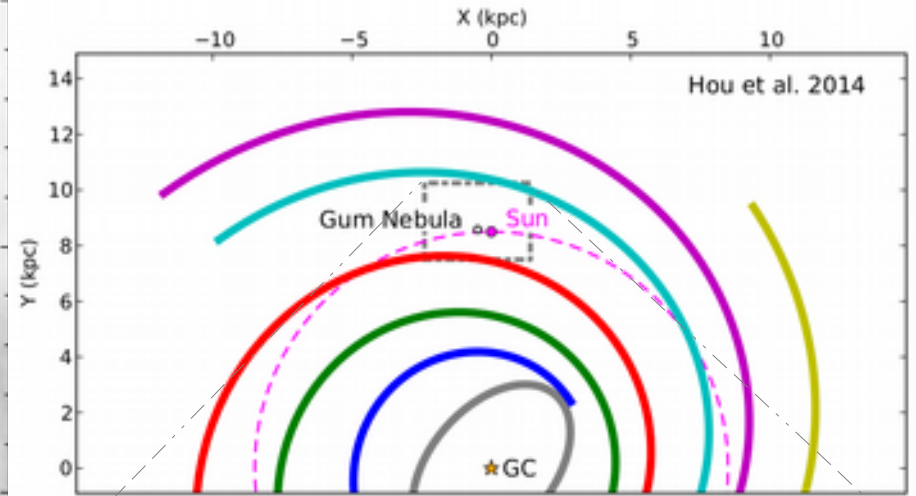
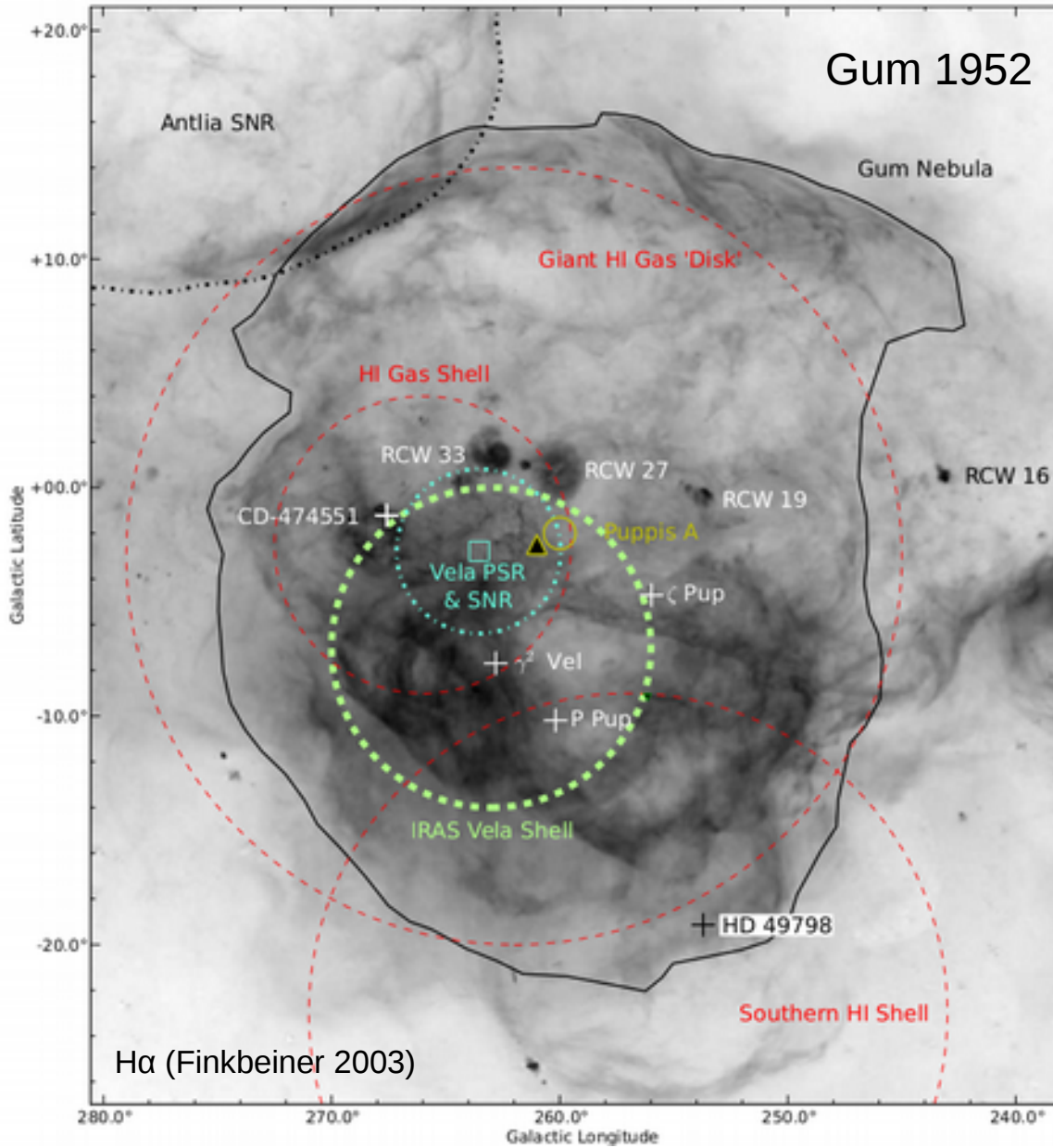


Magnetism in our Galaxy



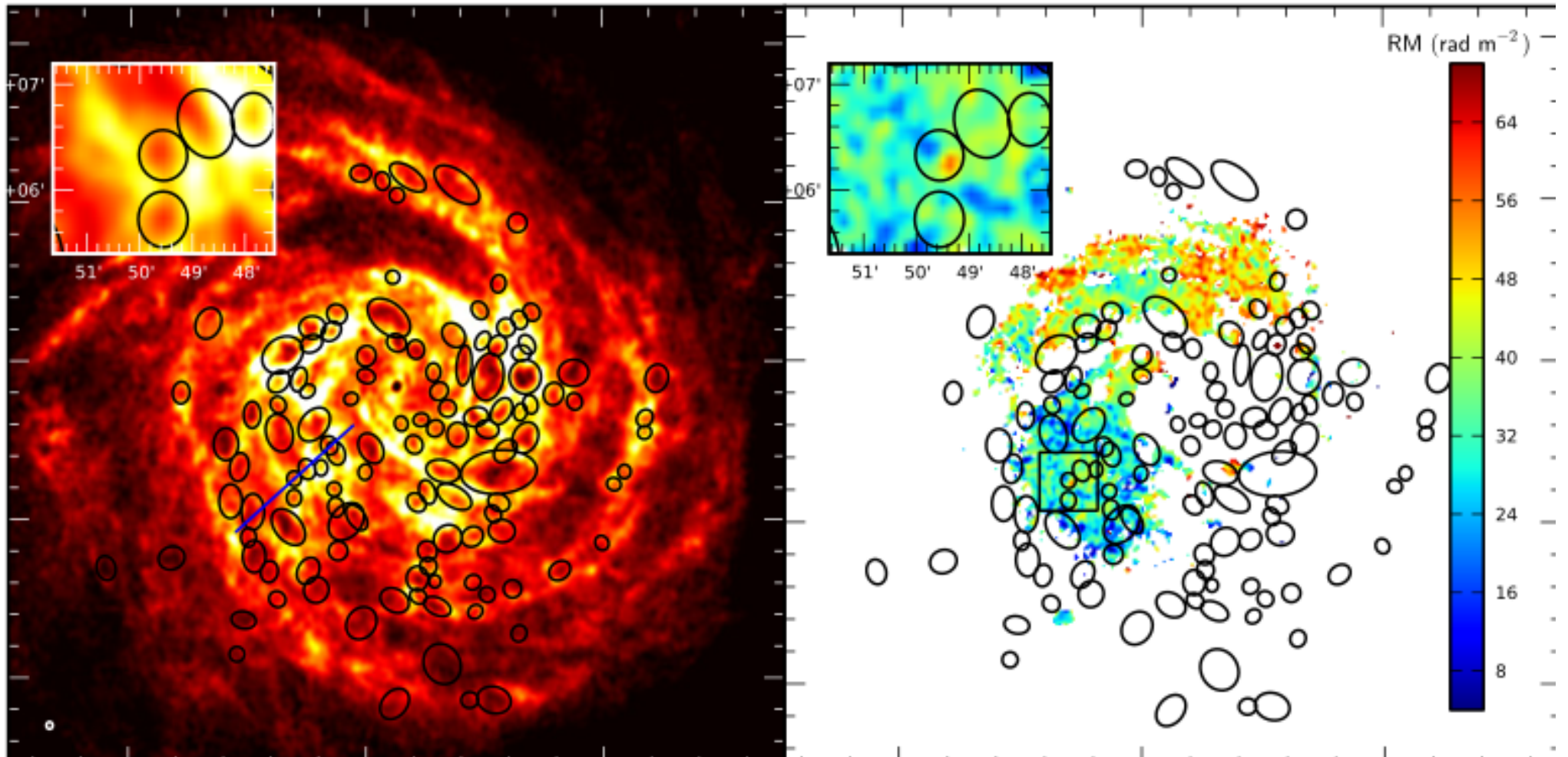


Magnetism in our Galaxy



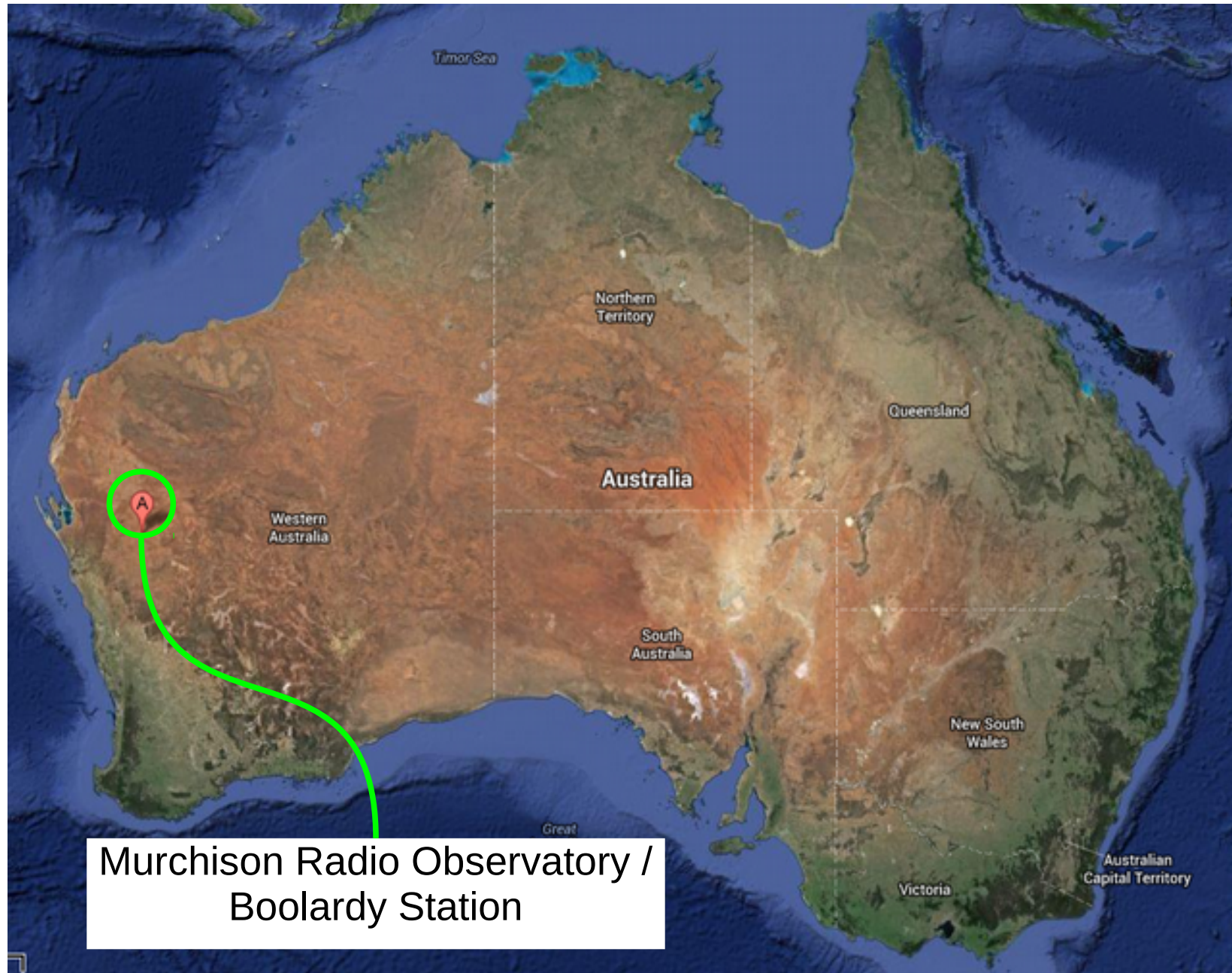


Magnetism in our Galaxy





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Summary

