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COSMIC MAGNETIC FIELDS

SEEING AND MEASURING THE *INVISIBLE*

Magnetic fields are everywhere around us.
Yet very little is known about their origin(s) and evolution.

See the colours dancing across the night sky in Alaska.

The Northern lights – also known as the aurora borealis – occur when charged particles in the solar wind interact with the Earth's magnetic field.

Background credit: The National Geographic's Short Film Showcase by Alexis Coram

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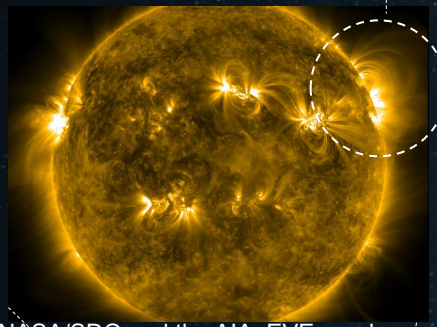
THE BIG PICTURE

Charged particles emit *light* as they spiral along the magnetic fields of the Sun and the Earth. Seeing the light allows us to trace the otherwise invisible magnetic fields!

Magnetic arches towering over the active solar surface



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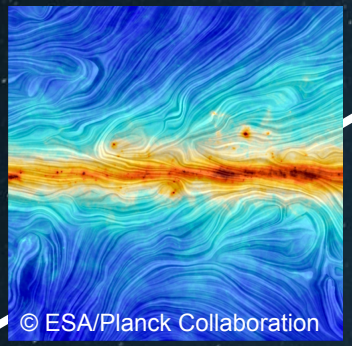
The direction of the polarised light emitted by *dust* tells us the magnetic field orientation.



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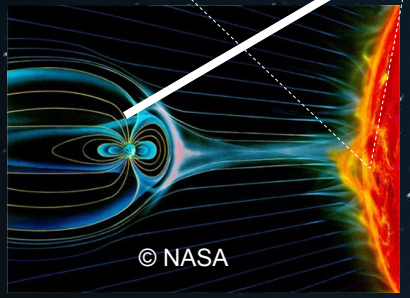
Magnetic fingerprint of our Galaxy – the Milky Way



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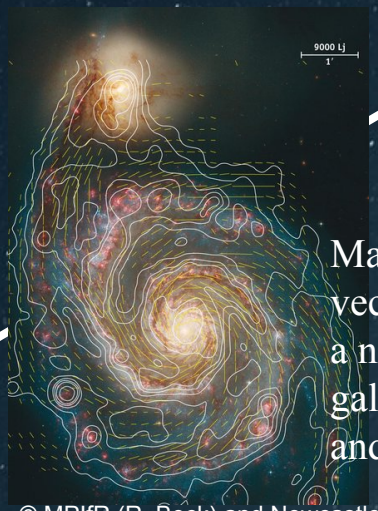
The solar wind carries with it the Sun's magnetic field that interacts with the Earth's magnetosphere (in blue).

Background credit: Just the night sky by Stefan Cosma

On *larger* scales, we use *radio* observations to trace the magnetic fields.

larger structure

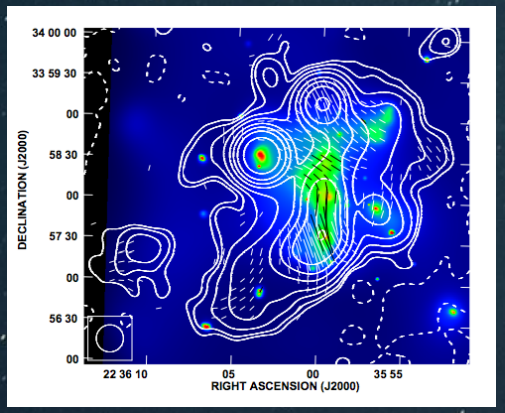
weaker field



Magnetic field vectors of a nearby galaxy – M51, and

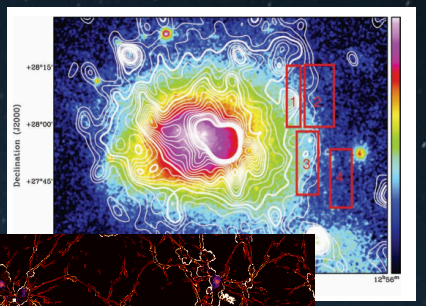
© MPIfR (R. Beck) and Newcastle University (A. Fletcher)

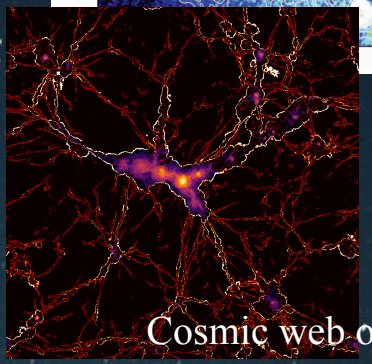
a galaxy group – Stephan's Quintet



© Nikiel-Wroczyński+ (2013)

Coma cluster © Brown+ (2011)



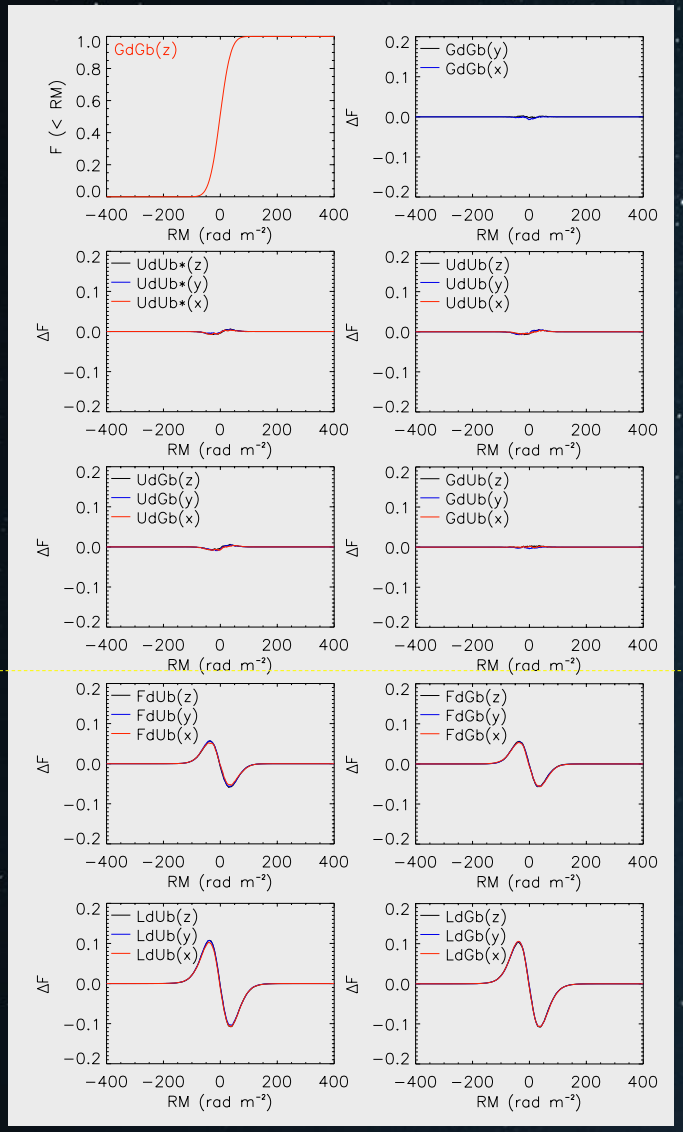


Cosmic web of filaments and voids

© TNG Collaboration

Can we similarly infer the magnetic field properties in galaxy clusters and beyond?

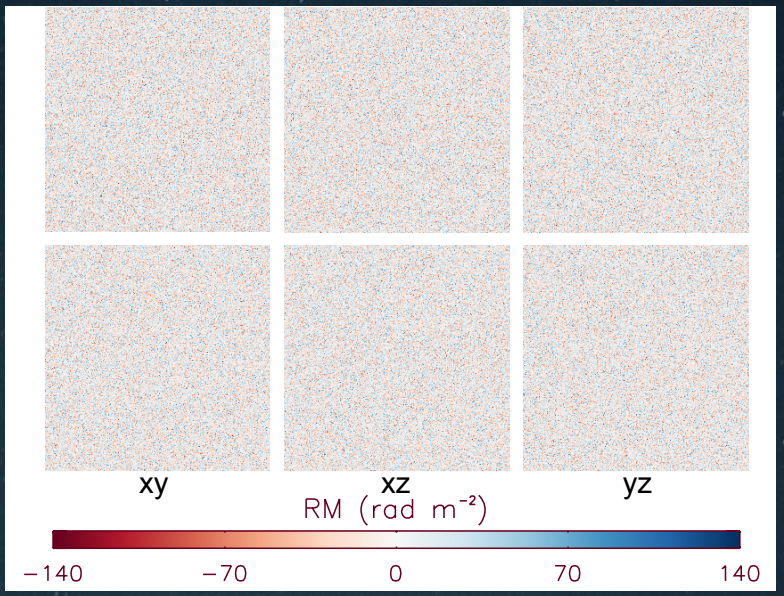
SOME RESULTS



Faraday rotation measure (RM) at radio wavelengths is commonly used to diagnose large-scale magnetic fields.

The correlations in the observed RM fluctuations (RMF) is used to probe the length scales on which magnetic fields vary.

We examine the conventional RMF analyses for magnetic field diagnostics in the context of polarised radiative transfer.



The conventional RMF analyses *do not work* for fractal and lognormal density distributions.

The conventional RMF analyses *cannot distinguish* between the RM maps, where the top panels are generated from Gaussian-distributed densities and magnetic field strengths, whereas the bottom panels from uniformly-distributed densities and magnetic field strengths.

Background credit: Just the night sky by Stefan Cosma

TAKE-HOME MESSAGES

- We caution against interpretations of RMF analyses when the characteristic density is ill-defined – e.g. lognormal-distributed and fractal-like density structures.
- Density fluctuations can mask the effect of magnetic field fluctuations, affecting the correlation length of magnetic fields inferred from the conventional RMF analyses.
- The spatial correlations are generally not the same along the line-of-sight and across the sky plane.
- In complex situations, a covariant polarised radiative transfer calculation is essential to properly track all radiative and transport processes, otherwise the interpretations of magnetism in galaxy clusters and larger scale cosmological structures would be ambiguous.

THE AUTHOR

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On+ (2019)

Chan+ (2018)

Background credit: Just the night sky by Stefan Cosma