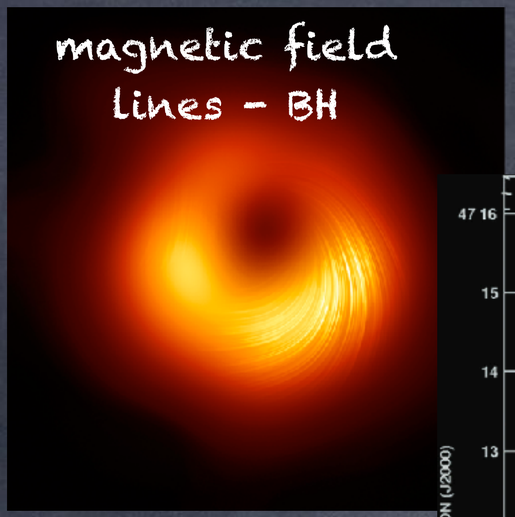
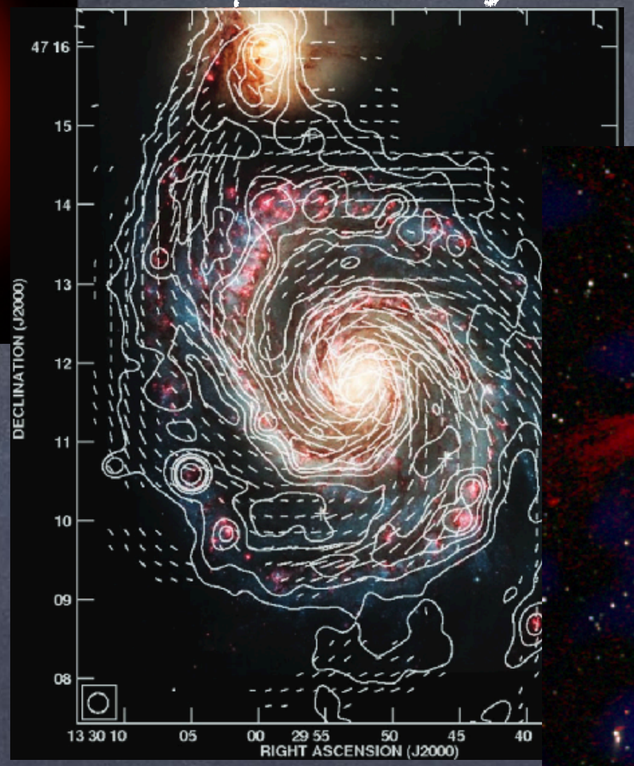
Magnetic fields in astrophysics

Prof. Annalisa Bonafede

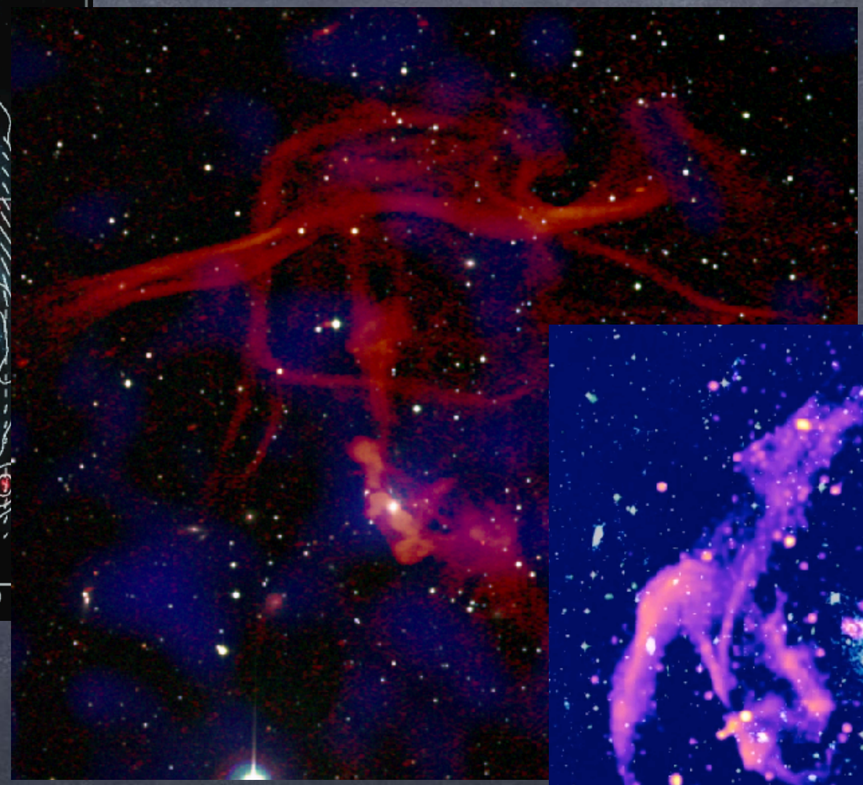
magnetic field lines - BH



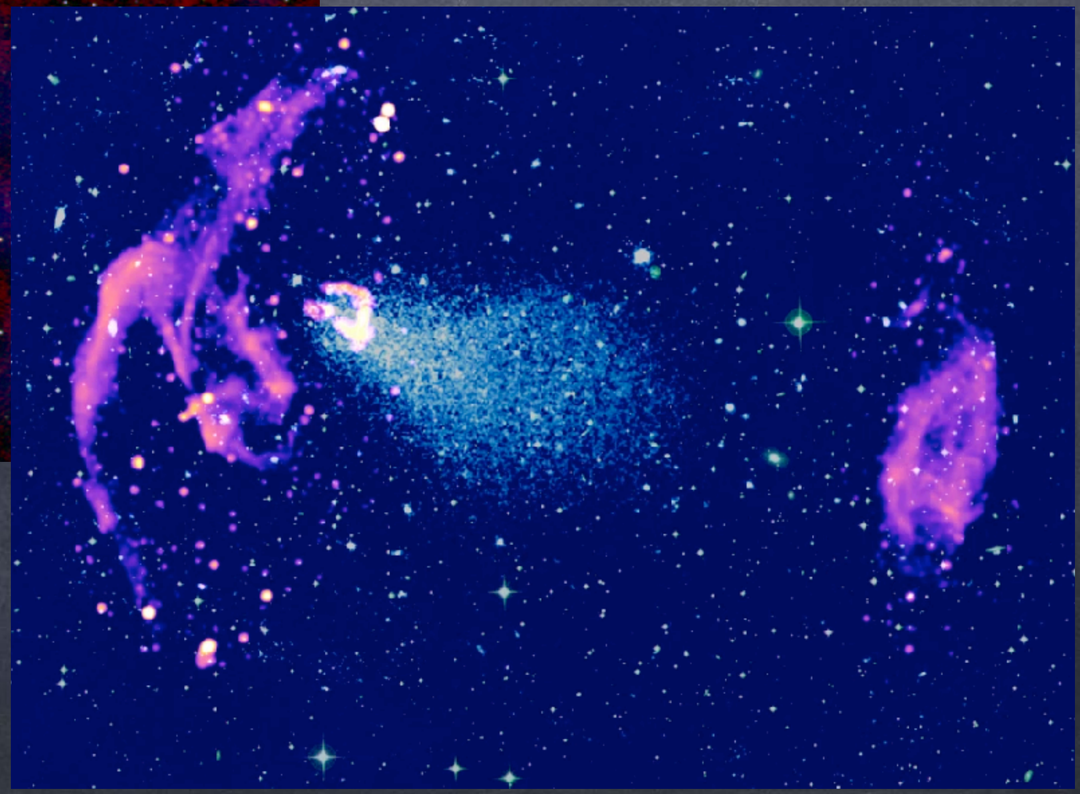
magnetic field lines - spiral galaxy



magnetic field shapes plasma in galaxy groups



and clusters of galaxies



Program - Magnetic fields theory and observations

- ✓ Magnetohydrodinamics: basic equations and essential parameters
- ✓ Techniques: how do we study magnetic fields?
- ✓ Magnetic field in the Milky Way
- ✓ Magnetic fields in galaxies and AGN
- ✓ Magnetic fields in clusters of galaxies
- ✓ Origin and amplification of magnetic fields in the Universe
- ✓ Magnetic fields in the cosmic web (?)

Theoretical part

Basic equations (starting from Maxwell equations)

MHD equation

Non MHD approximation

Dynamo amplification

- small scale-dynamo
- alpha-Omega dynamo

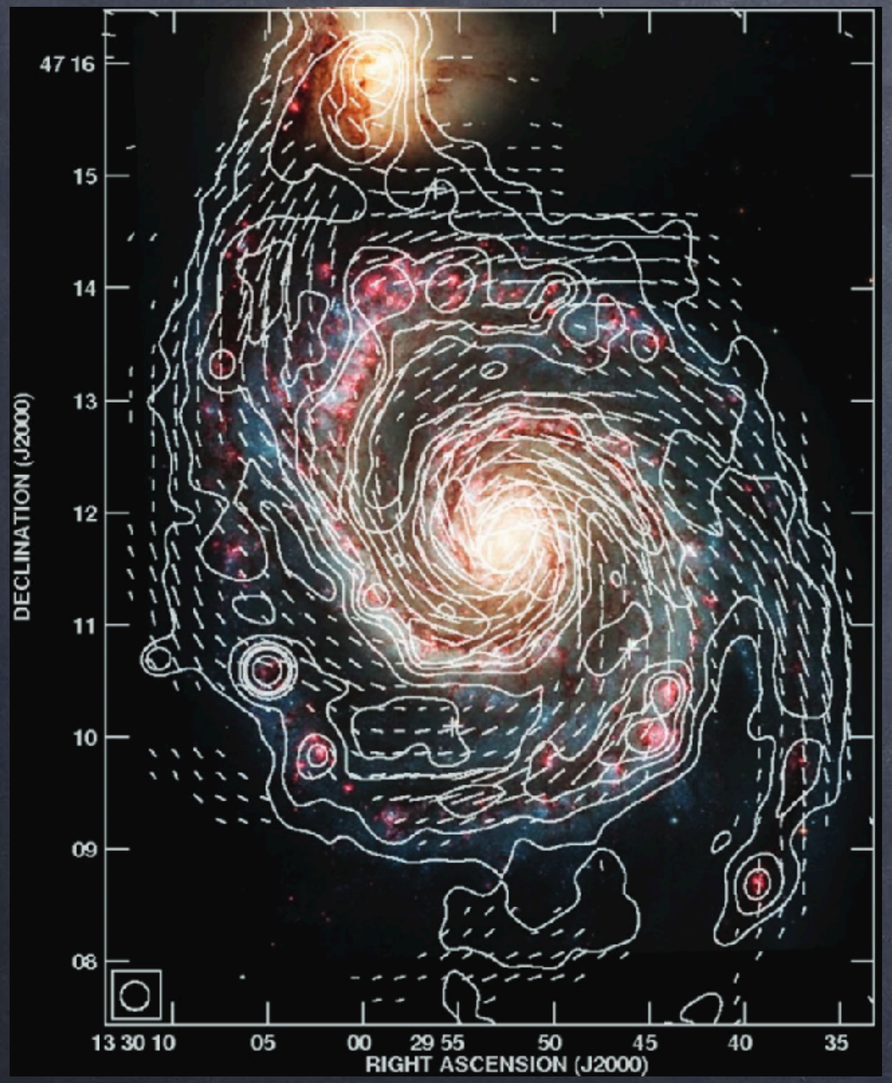
MHD waves (Alf'ven and magneto sonic waves)

Techniques

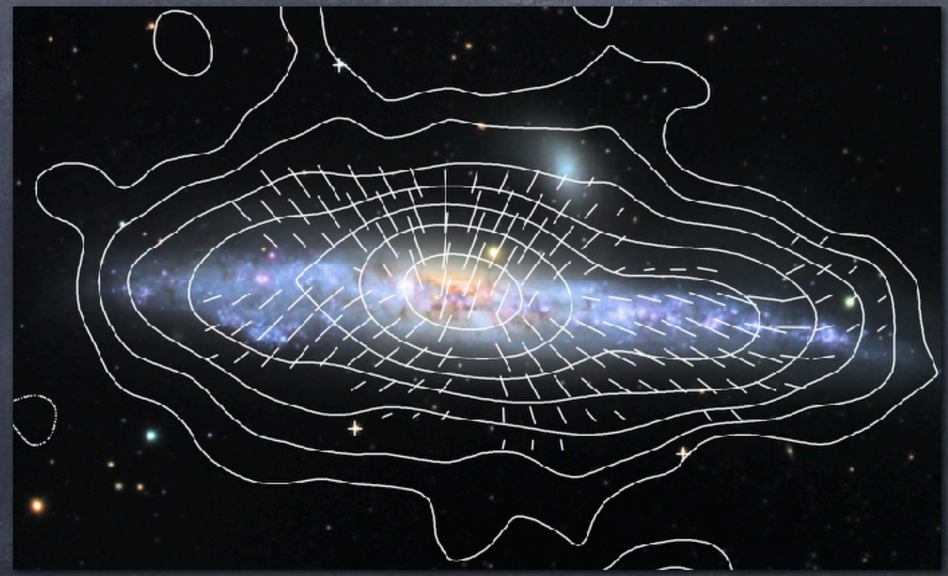
Observational diagnostics to observe magnetic fields
and techniques to constrain them

- Radio Equipartition
- Faraday Rotation Measure and RM synthesis
- Polarisation
- Inverse-Compton / Synchrotron
- Zeeman effect
- Polarised emission from dust grains

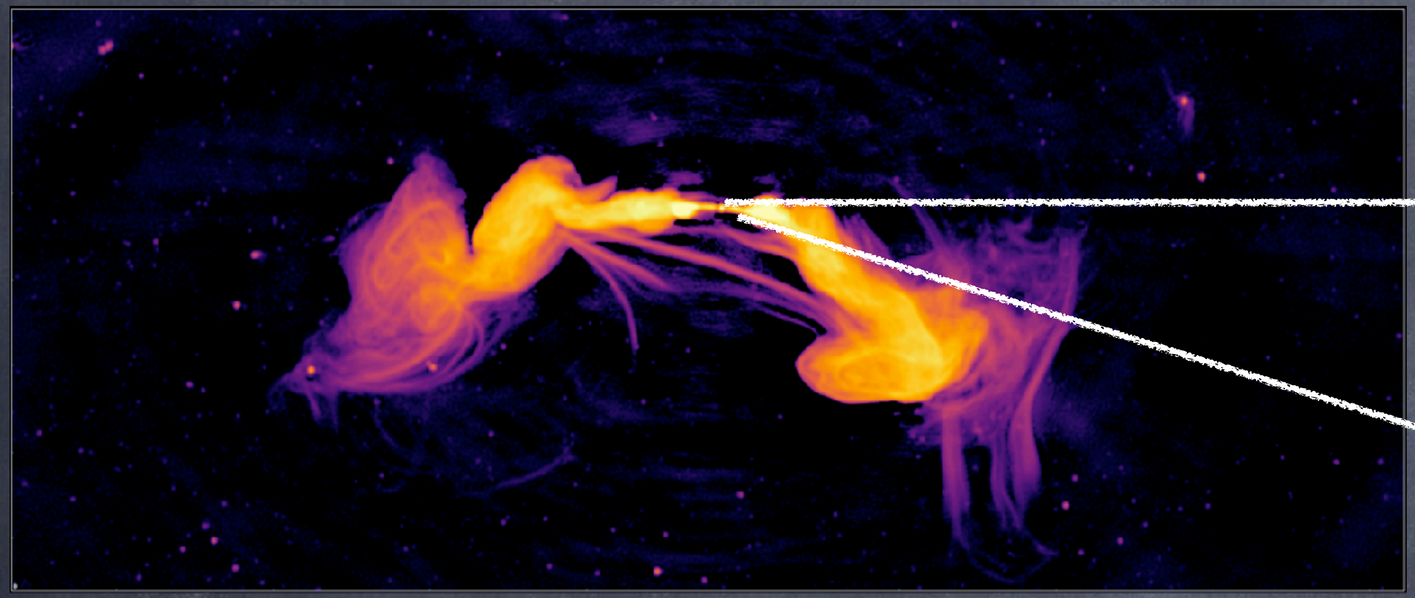
Magnetic fields in galaxies

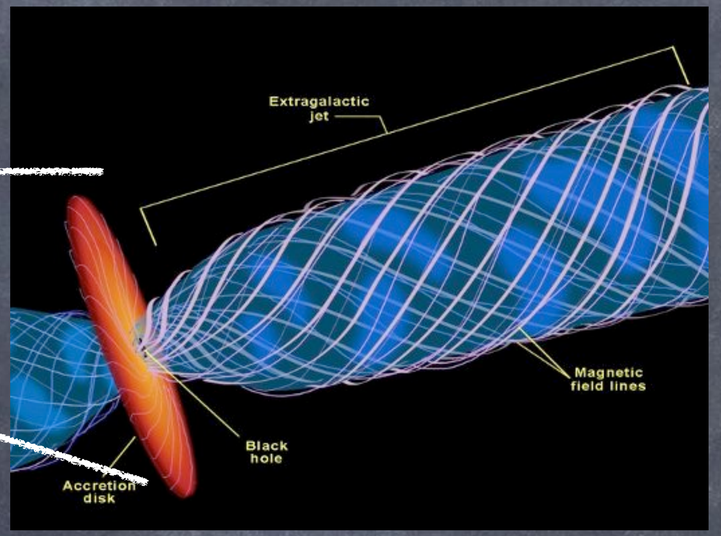


- What do we observe?
- effect on dynamics of the gas?
- effect on thermal conduction?
- strength: dynamo amplification



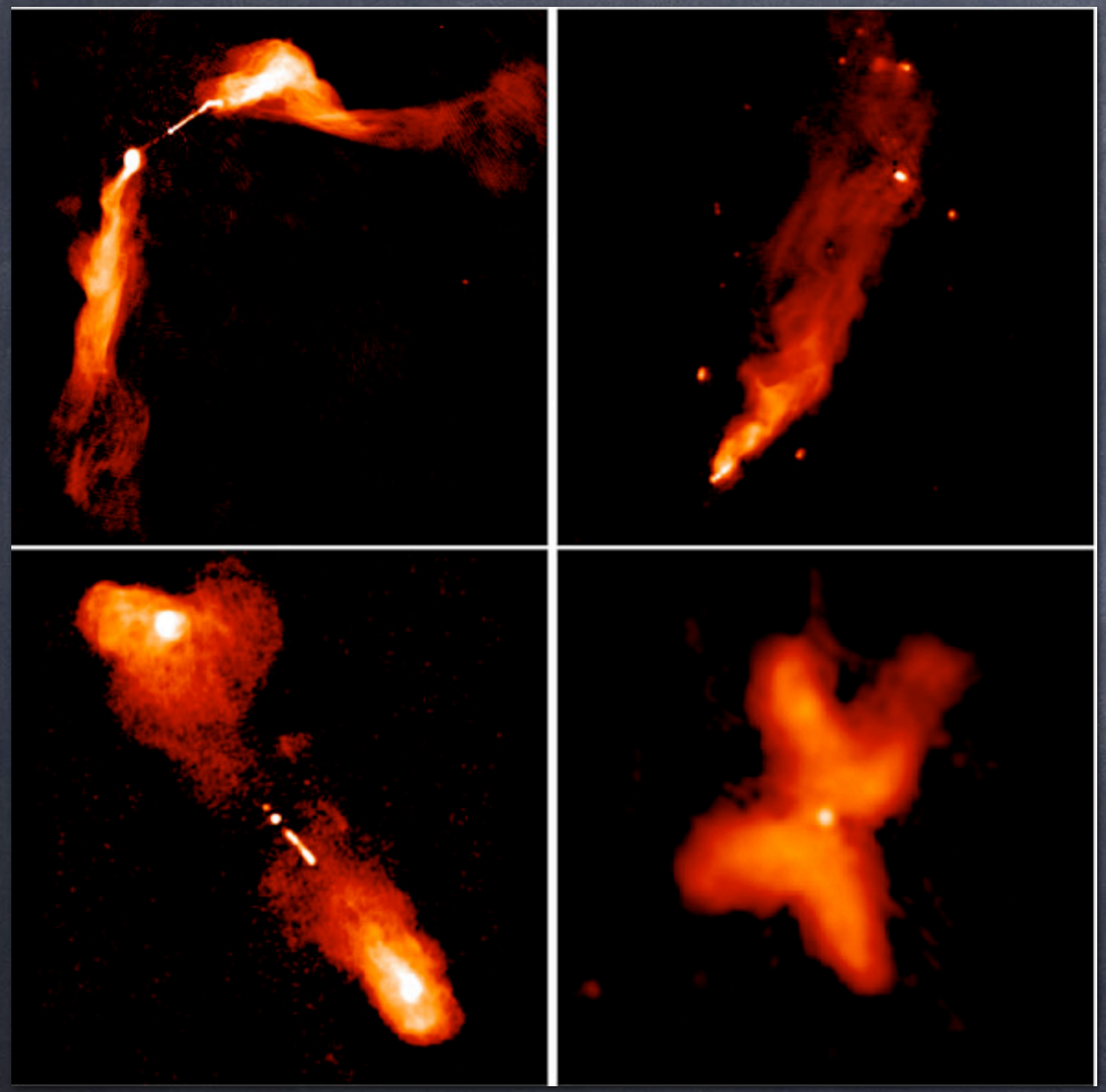
Magnetic fields in AGN





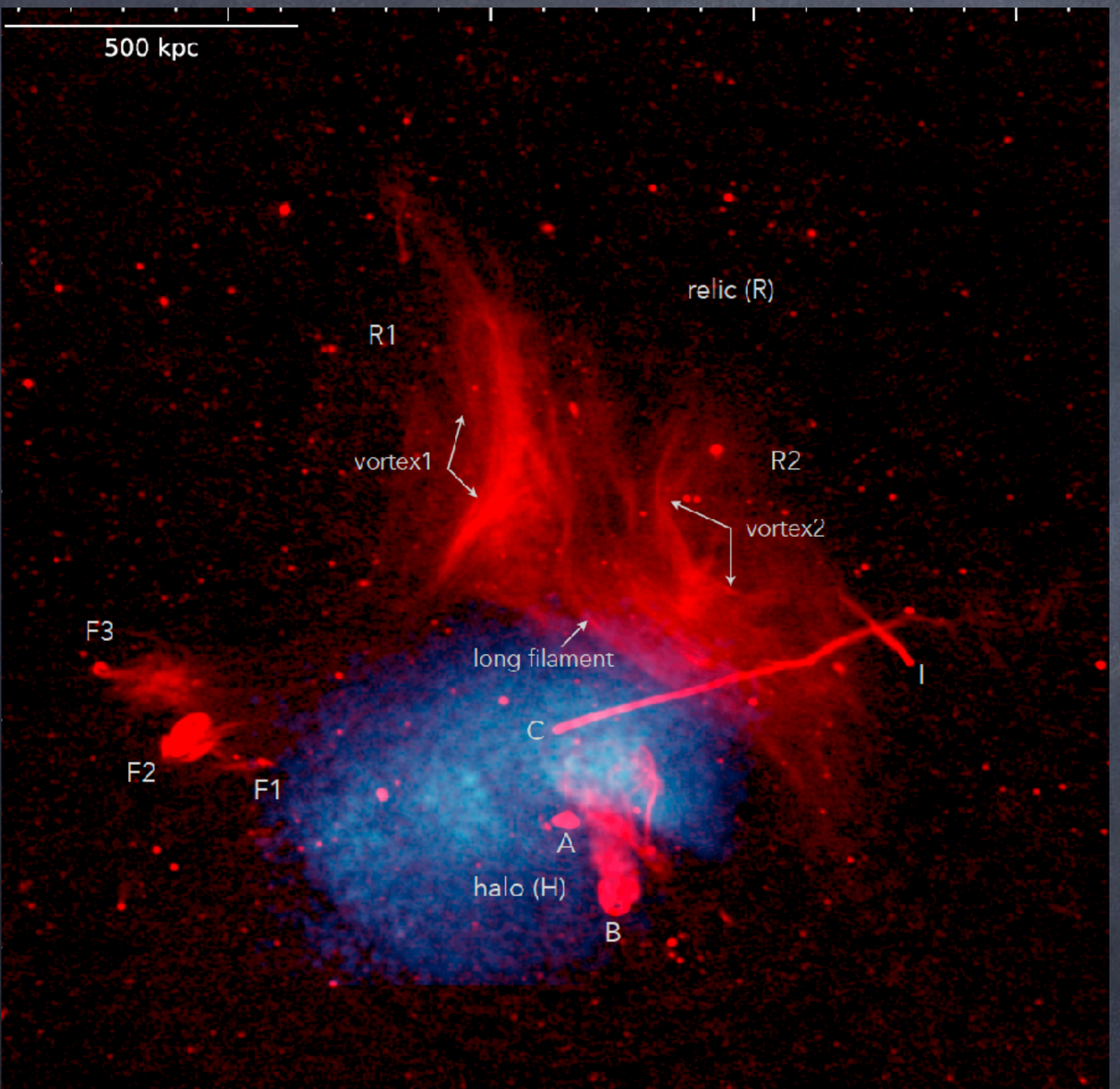
- What do we know from observations?
- Models for jet Magnetic field

Magnetic fields in AGN



100s kpc
scale emission in AGN

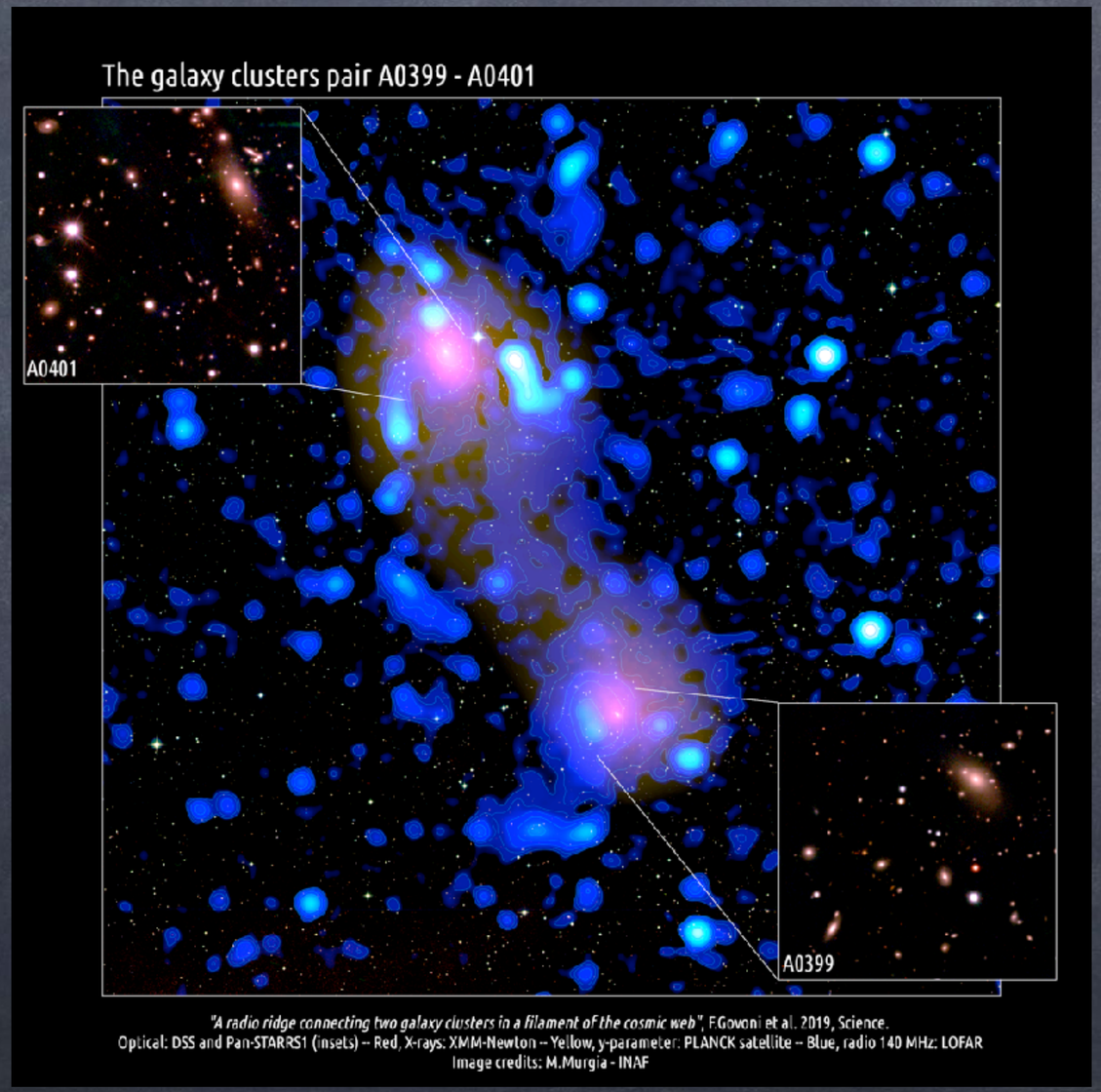
Magnetic fields on larger scales: galaxy clusters



- Observations of large-scale emission powered by shocks accelerating particles in presence of a magnetic field

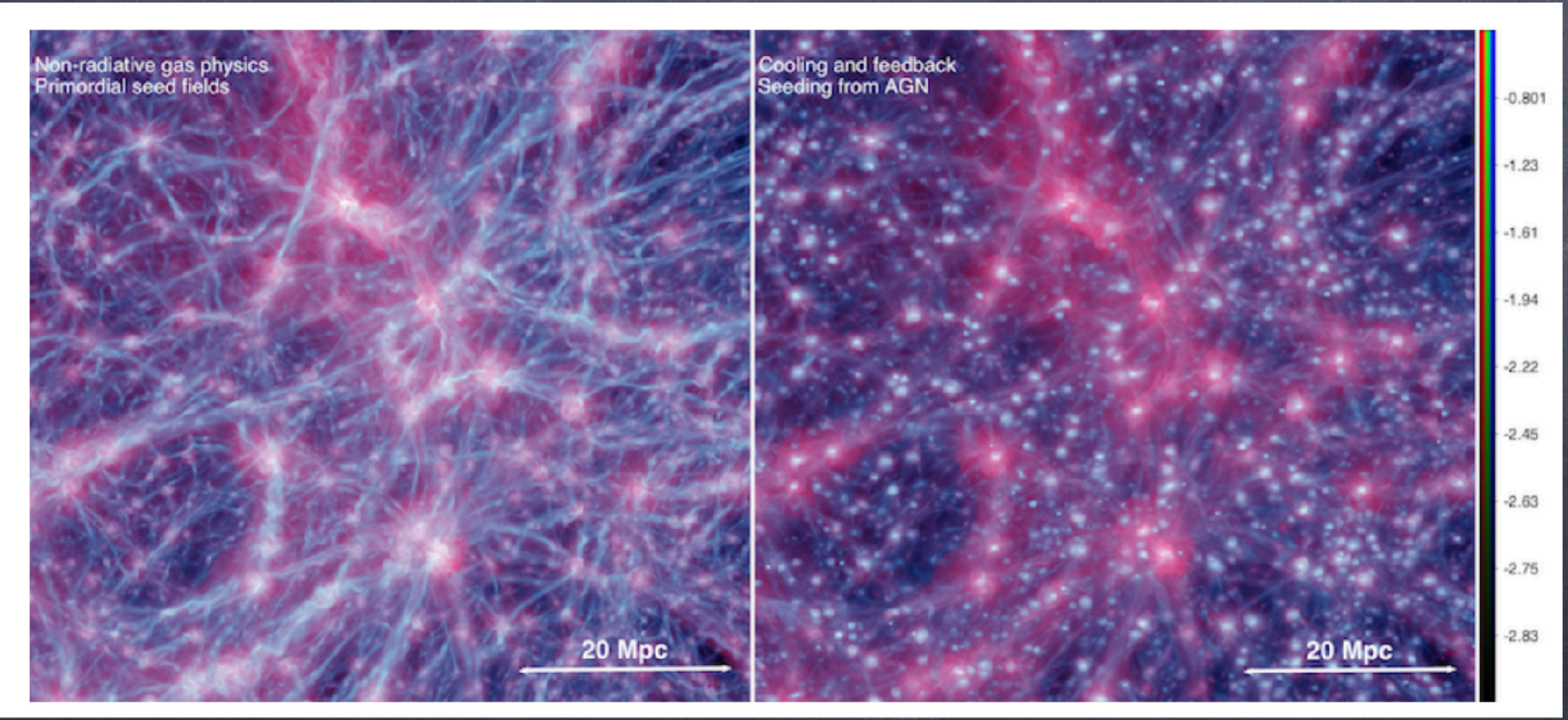
Magnetic fields on larger scales: galaxy clusters

Magnetic fields outside clusters: filaments and the cosmic web



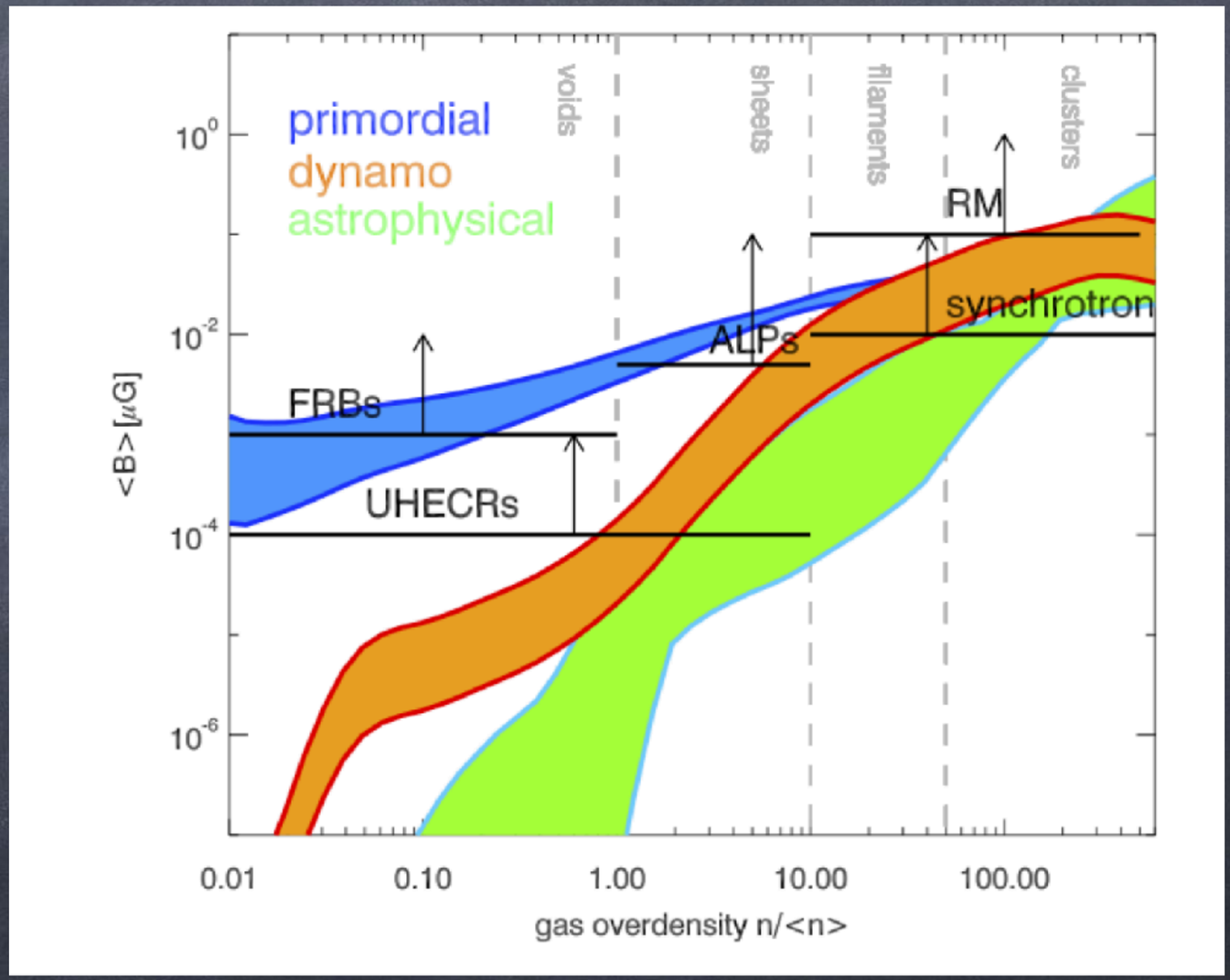
Magnetic fields - origin

- Origin yet unknown



Magnetic fields origin

- Origin yet unknown cosmological or astrophysics?



Program: magnetic field in practice

techniques to derive magnetic field estimates from data (already reduced and ready to be analysed)

Radio - mm band are the most used

Laboratory - How do we infer magnetic field properties from data?

New instruments built in the last and next years have magnetic field studies as primary goals - big involvement of italian community

LOFAR

SKA the Square Kilometre Array

The final exam:

Send written a report (few pages) about one of the lab exercises

The oral exam starts with the presentation of one of the lab exercises (1/2 of the exam)

2 questions on the topics covered during the course