

Observations of magnetic fields in galaxies

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Magnetic Fields in the Universe:
From Laboratory and Stars to Primordial Structures III
Zakopane, August the 25th, 2011

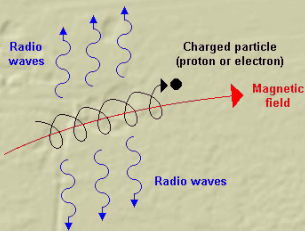
outline

- ▶ how to observe
- ▶ observed strength and configuration
 - ▶ in normal galaxies
 - ▶ in flocculents and dwarfs
 - ▶ in perturbed ones
 - ▶ in galactic halos
 - ▶ between galaxies
- ▶ future prospects & summary

how to observe

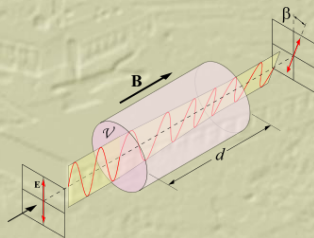
synchrotron radiation

$$I_{\text{sync}} \propto B_{\perp}^{\alpha} N_{\text{rel}}$$



Faraday rotation

$$RM \propto B_{\parallel} N_{\text{th}}$$



instruments

interferometer array

- + resolution
- sensitivity



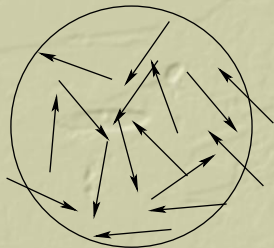
single dish

- resolution
- + sensitivity

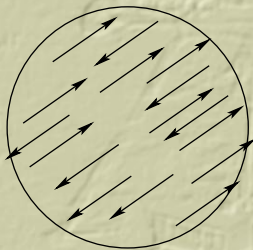


what sees the telescope

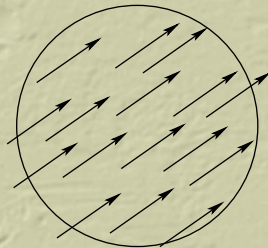
random field



anisotropic field



regular field



✓ total emission
polarized emission
Faraday rotation

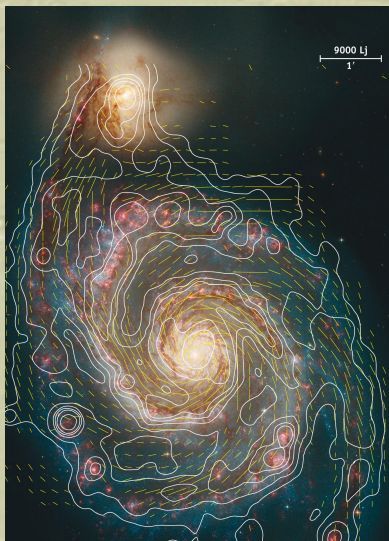
✓ total emission
✓ polarized emission
Faraday rotation

✓ total emission
✓ polarized emission
✓ Faraday rotation

depolarization

- ▶ thermal emission content ($\sim 25\%$ @ 6 cm)
- ▶ beam depolarization ($20'' - 10'$)
- ▶ Faraday depolarization
 - ▶ along the line of sight
 - ▶ across the beam
 - ▶ bandwidth

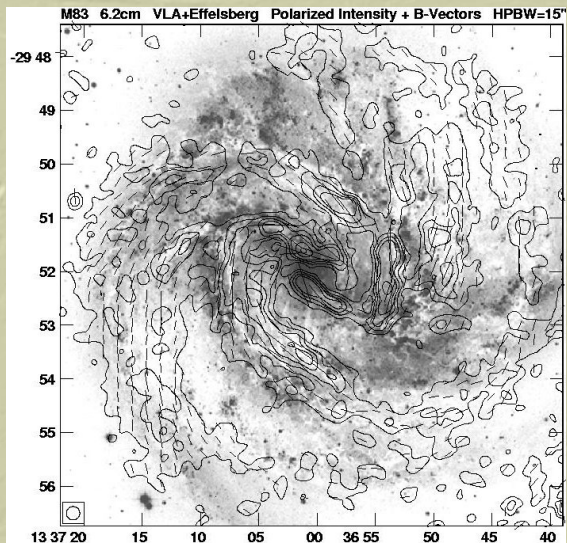
normal galaxies – M 51



- ▶ $B_{\text{tot}} \simeq 20 \mu\text{G}$
- ▶ $B_{\text{ord}} \simeq 10 \mu\text{G}$
- ▶ $B_{\text{reg}} \simeq 3 \mu\text{G}$

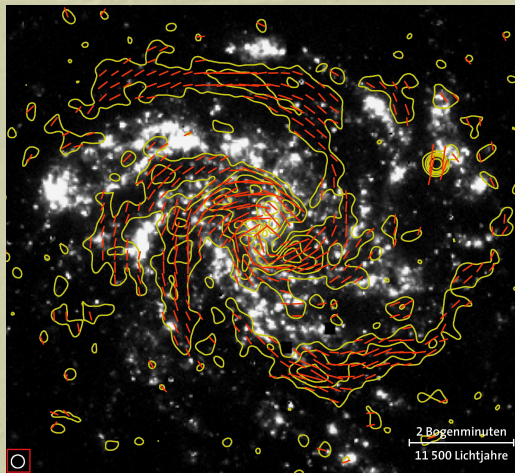
(Fletcher et al. MNRAS 2011)

normal galaxies – M 83



(R.Beck priv.com.)

normal galaxies – NGC 6946



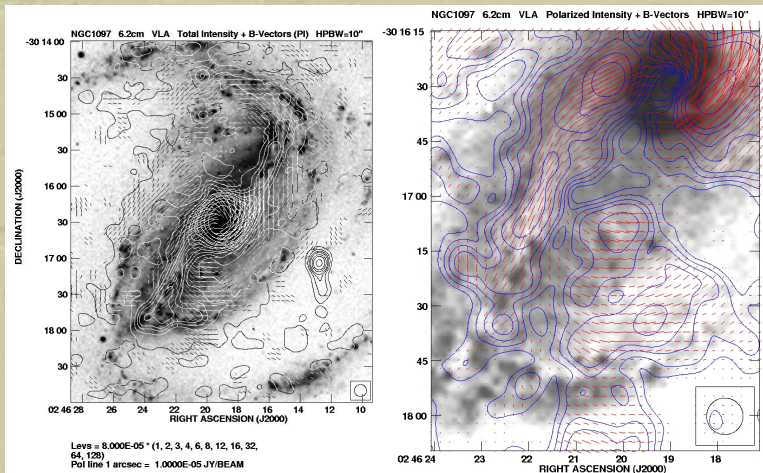
▶ $B_{\text{tot}} \simeq 20 \mu\text{G}$

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(Beck A&A 2007)

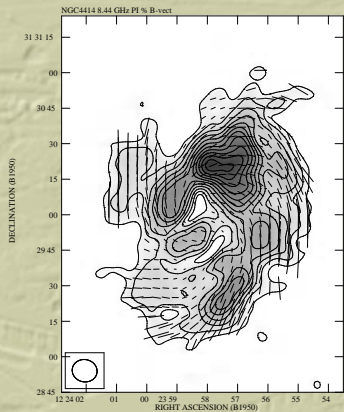
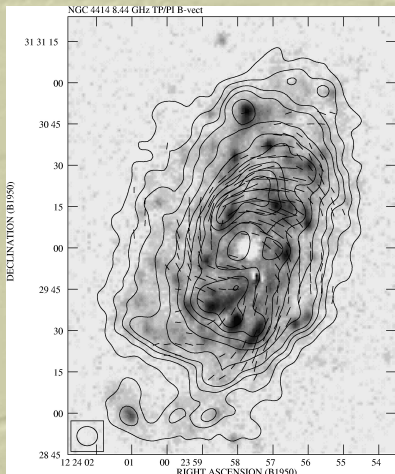
normal galaxies – NGC 1097



$$B_{\text{tot}} \simeq 25 \mu\text{G}; B_{\text{ord}} \simeq 10 \mu\text{G}; B_{\text{reg}} \simeq 4 \mu\text{G}$$

(Beck et al. A&A 2005)

flocculent galaxies – NGC 4414

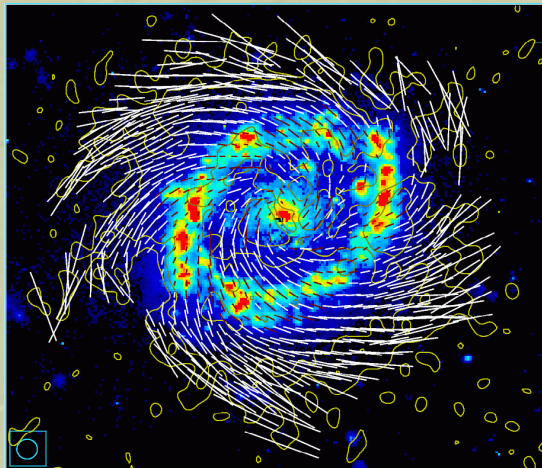


▶ $B_{\text{tot}} \simeq 15 \mu\text{G}$

▶ $B_{\text{ord}} \simeq 4 \mu\text{G}$

(Soida et al. A&A 2002)

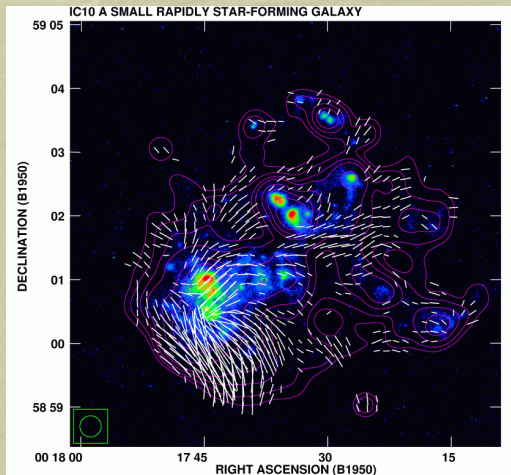
ringed galaxy – NGC 4736



- ▶ $B_{\text{tot}} \simeq 30 \mu\text{G}$
- ▶ $B_{\text{ord}} \simeq 15 \mu\text{G}$
- ▶ $B_{\text{reg}} \simeq 15 \mu\text{G}$

(Chyży & Buta ApJL 2008)

dwarfs – IC 10

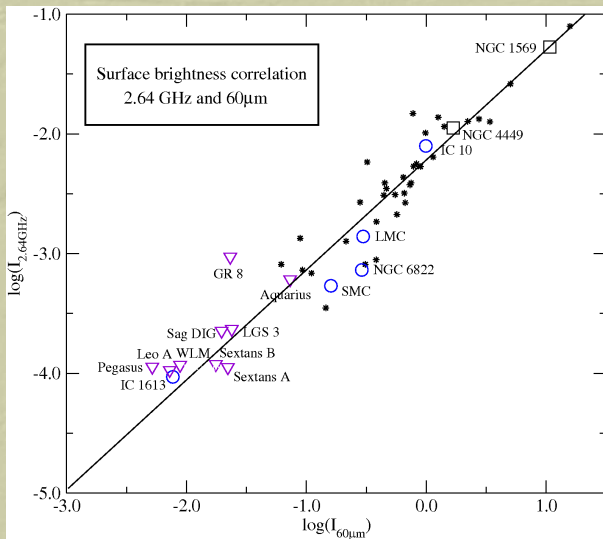


▶ $B_{\text{tot}} \simeq 10 \mu\text{G}$

▶ $B_{\text{ord}} \simeq 1 \mu\text{G}$

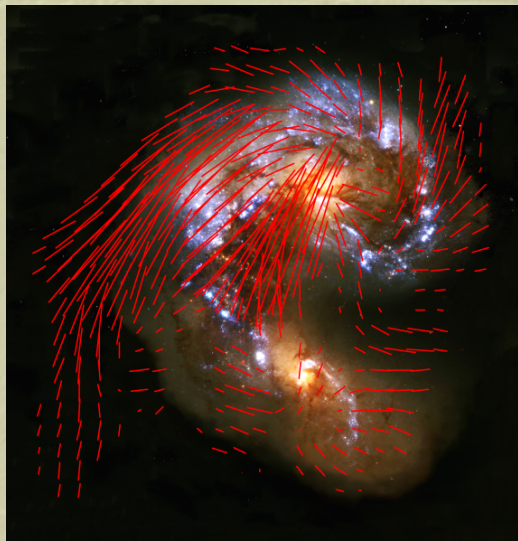
(Chyży 2005, and in prep.)

radio – IR correlation



(Chyży et al. A&A 2011, see also poster)

interacting galaxies – NGC 4038/39



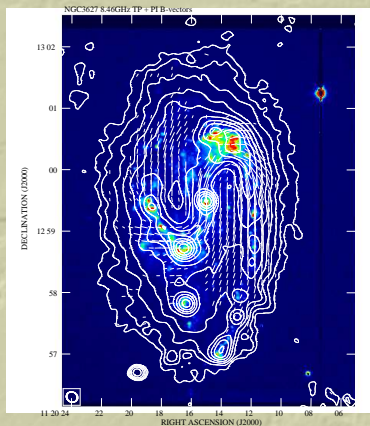
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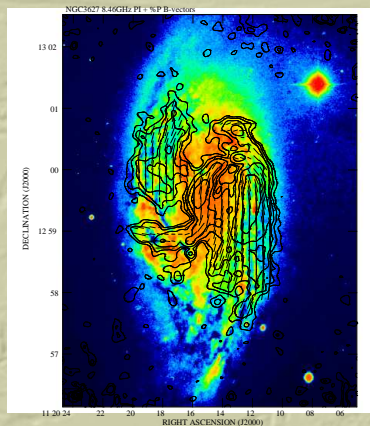
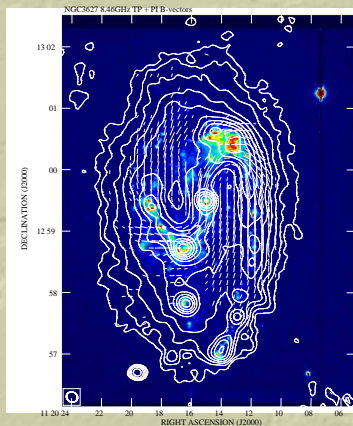
▶ $B_{\text{reg}} \simeq 10 \mu\text{G}$

(Chyży & Beck A&A 2004)

interacting galaxies – NGC 3627



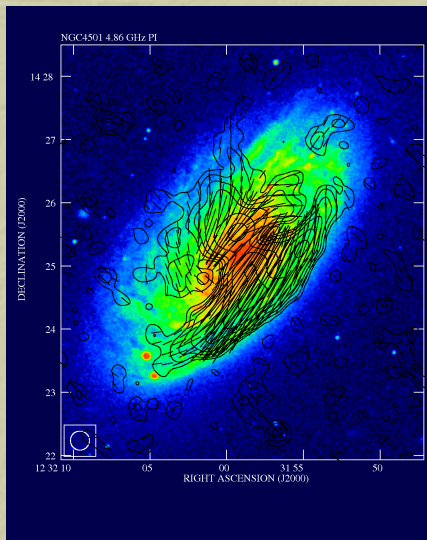
interacting galaxies – NGC 3627



$$B_{\text{tot}} \simeq 12 \mu\text{G}; B_{\text{ord}} \simeq 5 \mu\text{G}$$

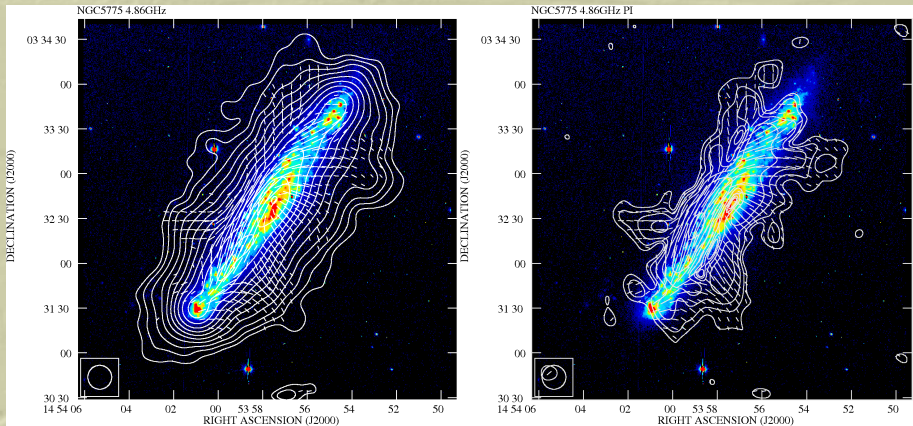
(Soida et al. A&A 2001)

clustered galaxies – NGC 4501



(Vollmer et al. A&A 2007)

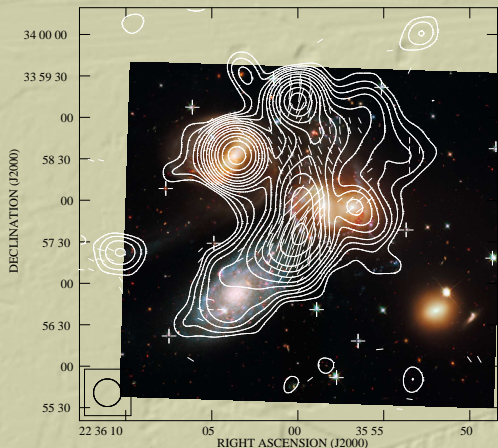
in a halo – NGC 5775



$$B_{\text{tot}} \simeq 10 \mu\text{G}; B_{\text{ord}} \simeq 4 \mu\text{G}; B_{\text{reg}} \simeq 4 \mu\text{G}$$

(Tüllmann et al. A&A 2000, Soida et al. A&A 2011)

between galaxies – HCG 92



$$B_{\text{tot}} \simeq 10 \mu\text{G}; B_{\text{ord}} \simeq 2 \mu\text{G}$$

(Soida et al. in prep.)

summary

- ▶ spiral galaxies possess magnetic field with $B_{\text{tot}} \simeq 10\text{--}100 \mu\text{G}$
- ▶ it's ordered component is $B_{\text{ord}} \simeq 5\text{--}20 \mu\text{G}$
- ▶ magnetic field line are oriented (mostly) along optical spiral arms
- ▶ field regularity is higher between spiral arms
- ▶ polarized intensity distribution forms a magnetic arms
- ▶ but field strength is higher in arms
- ▶ the X-shaped field configuration is seen in edge-on spirals
- ▶ interaction implies asymmetries in magnetic field strength, regularity, orientation
- ▶ no clear border between interstellar and intergalactic magnetic field in close groups (and clusters)

future

- ▶ VLA, Effelsberg, ATCA, Parkes have ~ 30 years
- ▶ new instruments are coming – EVLA, LOFAR, SKA, ...
- ▶ broad bandwidth, low frequencies, large collecting area, ...
- ▶ higher sensitivity, better resolution
- ▶ new techniques – rotation measure synthesis

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- ▶ ...