Cluster Magnetic Fields through the Study of Polarized Radio Halos

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On behalf of the SKA Cosmic Magnetism Working Group

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Magnetic Fields in Galaxy Clusters

A2255

Optical
Magnetic Fields in Galaxy Clusters

A2255

Optical - X-ray
Magnetic Fields in Galaxy Clusters

Optical - X-ray - Radio

Radio Halo

1 Mpc

Optical - X-ray - Radio
Magnetic Fields in Galaxy Clusters

- The detection of polarized emission from radio halos has been shown extremely important to investigate intra-cluster magnetic fields. Murgia et al. (2004), Govoni et al. (2006), Vacca et al. (2010)

- Detecting this polarized signal is a very hard task with current instruments. So far only in A2255 and MACSJ0717.5+3745 filaments of polarized emission have been detected in the radio halo.
Polarization of Radio Halos

A2255

Govoni et al. (2005), see also Pizzo et al. (2009)
Polarization of Radio Halos

MACS J0717.5+3745
Bonafede et al. (2009)
SEED MAGNETIC FIELDS INJECTED BY HIGH-Z AGNs ARE SPREAD AND AMPLIFIED TO $\mu$G LEVELS BY THE INTRA-CLUSTER TURBULENCE CAUSED BY MERGERS DURING THE CLUSTER FORMATION PROCESS.

Cosmological Simulations

Cosmological MHD simulations have been playing an important part in studying cluster magnetic fields

- Dolag et al. (1999, 2002), Bruggen et al. (2005), Dolag & Stayszyn (2009),
- Dubois & Teyssier (2008), Donnert et al. (2009), Xu et al. (2009, 2010), Bonafede et al. (2011),
- Iapichino & Bruggen (2012)

Gas Density

Magnetic Fields

Xu et al. (2012)
Cosmological Simulations

Simulated X-ray images 0.1-2.4 keV

Xu et al. (2012)

Simulated Radio halo images 1.4 GHz

$\langle B_0 \rangle = 2.5 \mu G$

$\langle B_0 \rangle = 1.0 \mu G$

$\langle B_0 \rangle = 0.5 \mu G$
Observations – Simulations Comparison

X-ray luminosity – Radio power relation in radio halos

Largest Linear size – Radio power relation in radio halos

Xu et al. (2012)
Polarization of Radio Halos

Full resolution radio halo emission
Frequency 1.4 GHz
Bandwidth 25 MHz
Polarization of Radio Halos

Frequency 1.4 GHz
Bandwidth 25 MHz
Resolution 50''
$\sigma I = 0.1 \text{ mJy/beam}$

Govoni et al. (2013)
In these simulations we applied the Faraday-Synthesis to recover polarized signal reduced by the bandwidth depolarization e.g. Brentjens & de Bruyn (2005), Pizzo et al. (2011).
Polarized Intensity of Radio Halos

Frequency 1.4 GHz - Bandwidth 300 MHz - Resolution 15"

σI = 10 μJy/beam

Survey WODAN with APERTIF
Survey POSSUM with ASKAP
Polarized intensity surface brightness as a function of the beam size

The simulated surface brightness is compared with the sensitivity of wide band instruments (SKA1, SKA2) to explore their potential in detecting the polarized intensity emission of halos of different radio power.

Govoni et al. (2013)
Conclusions

● Radio halos are intrinsically polarized at full resolution.

● Polarized signal is undetectable if observed with the resolution and sensitivity of current interferometers.

● Surveys planned with the SKA precursors (WODAN, POSSUM) will be in principle able to detect the polarized emission in the most luminous halos known.

● SKA could have the sufficient sensitivity to detect the polarized emission of strong and intermediate radio halos at high resolution