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Extra-galactic projects with NenuFAR

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Radio galaxies at low v

Radio jets at low frequency Old extent of the previous jets

Radio jets at high redshift: At z=6-9, ~10 times lower v Hydra-A, at 74GHz (4m) With the VLA: much more extended Ageing jets steepen their slope



History of the AGN feedback?

Low-frequency spectrum of radio jets





Global Halo age 40Myr



LOFAR-HBA, 140MHz, De Gasperin et al 2012 20", rms=20mJy/beam, range =5000





No more extension at low frequency

No ageing, ~15 Myr -14 -14 -12 -1 -14 -12 -1 -14 -12 -1 -14 -15 -14 -14 -12 -1 -14 -15 -14 -15 -14 -15 -14 -15 -14 -15 -14 -15 -14 -15 -14 -15 -14 -15 -14 -15 -14 -15 -14 -15 -14 -15 -14 -15 -15 -14 -15 -14 -15 -14 -15 -14 -15 -14 -15

Spectral index map

FRII with hot spots, re-accelerating particles

Synergy with X-rays. Some sources are not more extended At low frequency



Radio-loud high-z quasars

106 000 Quasars in the Shen et al (2011) catalog (SDSS-DR7) Only 4 detected in radio at z>5. Above z~3 deficit of radio-jets

With respect to the blazars detected optically or X-rays



2 humps, synchrotron Inverse Compton

At high z, higher Energy in the CMB?

 $B\sim\!\!10\mu G$

Ghisellini et al ⁶14

CMB interaction at high z

 $U_{CMB} \sim (1+z)^4$ becomes larger than magnetic U_B Electrons cool by scattering off CMB photons, not synchrotron

Not in the relativistic jets in the center, but in the radio lobes



SED in the observer frame Comparison with F(v)=1mJy

And with LOFAR sensitivity

Ghisellini et al 14⁷

Advantage of LOFAR at high z

Models with different injection of energetic particles: two power-laws. Also variation of the B intensity In radio knots $U_B > U_{CMB} \rightarrow more \text{ contrast at high z}$



→ A lot to test at low-v

SED in the observer frame Comparison with F(v)=1mJy

And with LOFAR sensitivity

Ghisellini et al 14⁸

Relics in merging clusters

Radio relics: shocks due to the collision

The magnetic field can be boosted (compressed) in the merger

These shocks can have 1 Mpc sizes, and they are in general In the outer parts, sometimes symmetrically located

Diffusive shock acceleration (DSA) The Sausage: 610 MHz GMRT map Van Weeren et al 2010

Spectral index





Spectral index map, indicates ageing, with B~5 µG



Mach number~4 Down V ~1000km/s

Major merger 2:1

1Gyr ago

Magnetic field



Highly polarised emission

B=1-5 μG

Van Weeren et al 2010

Clusters in X-rays, Radio



Large number of low-z clusters Discovered with Planck-SZ

Followed up with XMM Unrelaxed clusters With radio halos



Planck-SZ

Coma. WSRT @352Mhz Brown & Rudnick '11



Shocks during cluster mergers



XMM-LOFAR Synergy

Tooth-brush puzzle:

How to produce a linear shock during a merger?



Colours: XMM Contours: GMRT 610 MHz green -> blue spectral index map

LOFAR tells us when clusters up to z=1 are ``relaxed"

With NenuFAR

Nen-1NenuFAR+ LOFARSpatial Resol 5° 1.5° 2''Sensitivity120-240mJy50-100mJy35-70mJy8h

Flux of detected relics between 5-10Jy

Could be detected up to z~1 With full NenuFAR+LOFAR

