PROBING THE NON-THERMAL EMISSION IN THE PERSEUS CLUSTER WITH THE JVLA

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AGN Mechanical Feedback

Virgo cluster
0.50 Ms Chandra
$z = 0.003$ (D = 19 Mpc)
*Forman et al. 2007*

Perseus cluster
1.4 Ms Chandra
$z = 0.018$ (D = 72 Mpc)
*Fabian et al. 2011*

NGC 5813 - Galaxy group
650 ks Chandra
$z = 0.0065$ (D = 30 Mpc)
*Randall et al. 2015*
Diffuse radio sources in galaxy clusters

1-Radio relic

“Toothbrush” RX J0603.3+4214
VLA 1-2 GHz radio contours
+ Chandra image
(van Weeren et al. 2016, Rajpurohit et al. 2017)

2-Radio halo

Abell 2146
1-2 GHz JVLA contours
(Hlavacek-Larrondo, Gendron-Marsolais et al. 2017)
+ Unsharp-masked Chandra
(Russell et al. 2010, 2012)

3-Mini-halo

Perseus
270-430 MHz JVLA contours (Gendron-Marsolais et al. 2017)
+ Chandra image
(Fabian et al. 2011)
The Perseus Cluster

- X-ray brightest cluster
- Nearby: $z = 0.018$, ~70 Mpc
- Relaxed cool core cluster
- BCG: NGC 1275
- Host a mini-halo
- Succession of cavities created by the jets of the central supermassive black hole, pushing away the gas and leaving buoyantly rising bubbles filled with radio emission.

SDSS i-band mosaic
+ Chandra composite fractional residual image (0.5-7 keV, 1.4 Ms exposure, Fabian et al. 2011)
+ 328 MHz VLA radio image (NRAO/VLA/G. Taylor)
NGC 1265

NGC 1275

NGC 1272

CR 15

IC 310

JVLA 230-470 MHz radio map in B-configuration
(5h, shared-risk proposal, PI Hlavacek-L.)
(rms =0.35 mJy/beam, beam 22.1’’ × 11.3’’)
Gendron Marsolais et al. 2017
SDSS i-band mosaic
+ 328 MHz VLA
(Credit: NRAO/VLA/G. Taylor, 1998)

SDSS i-band mosaic
+ JVLA B-array 270-430 MHz
(Gendron-Marsolais et al. 2017, NRAO press release)
• Several new structures identified: Mini-halos are not diffuse, uniform radio sources, but rather have a rich variety of complex structures

SDSS i-band mosaic + JVLA B-array 270-430 MHz (Gendron-Marsolais et al. 2017)
Chandra composite fractional residual image (0.5-7 keV, 1.4 Ms exposure, Fabian et al. 2011)
+ JVLA B-array 270-430 MHz (Gendron-Marsolais et al. 2017)
+ contours from SITELLE Hα flux map (starting at 3E10–17 erg/s/cm²/pixel)
  (Gendron-Marsolais et al. submitted)
- Mini-halo emission correlates with both the sloshing motion & AGN relativistic jets

- Emission avoids the southern bay (~ cold front but with opposite curvature, possibly caused by a Kelvin-Helmholtz instabilities, Walker et al. 2017)

Chandra composite fractional residual image (0.5-7 keV, 1.4 Ms, Fabian et al. 2011) + JVLA B-array 270-430 MHz contours from $5\sigma = 1.75 \text{ mJy/beam}$ to $1 \text{ Jy/beam}$
• Emission enclosed mostly behind the western sloshing cold front, fainter emission is also seen beyond, as if particles are leaking out.

GGM filtered image of the merged X-ray observations with Gaussian width $\sigma = 4$ pixels (Sanders et al. 2016) + JVLA B-array 270-430 MHz contours from $5\sigma = 1.75$ mJy/beam to 1 Jy/beam
Composite image

Public Prize of the national competition "Science Exposed" of the Natural Sciences and Engineering Research Council of Canada

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Gendron Marsolais et al. 2017
NGC 1265

Beam 18' = 400 kpc

NGC 1275

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CR 15

IC 310

2 GHz (92 cm)

3.8 GHz (49 cm)

Sijbring & de Bruyn 1998 (WSRT)
Detection with the *Fermi*-Large Area Telescope (LAT) at energies above 30 GeV (Neronov et al. 2010) + with the MAGIC telescopes above 260 GeV (Aleksic et al. 2010).
NGC 1265

CR 15

IC 310

Beam 18'' = 400 kpc

JVLA 230-470 MHz radio map in B-configuration

Kadler et al. 2012

NVSS VLA 1.4 GHz (1993) + VLBA 7.9–8.8 GHz (2011)
Illustrate the high-quality images that can be obtained with JVLA at low radio-frequencies, as well as the necessity to obtain deeper, higher-fidelity radio images of extended emission in clusters to further understand their origin.

Filaments everywhere!

Future work with the radio JVLA observations of Perseus:

- Complete A+B+C+D configurations 230-470 MHz JVLA datasets (including awarded 4h director’s discretionary time proposal + 5h regular proposal, both PI: G.-Marsolais)