Tight connection between the radio halo emission and the thermal ICM properties

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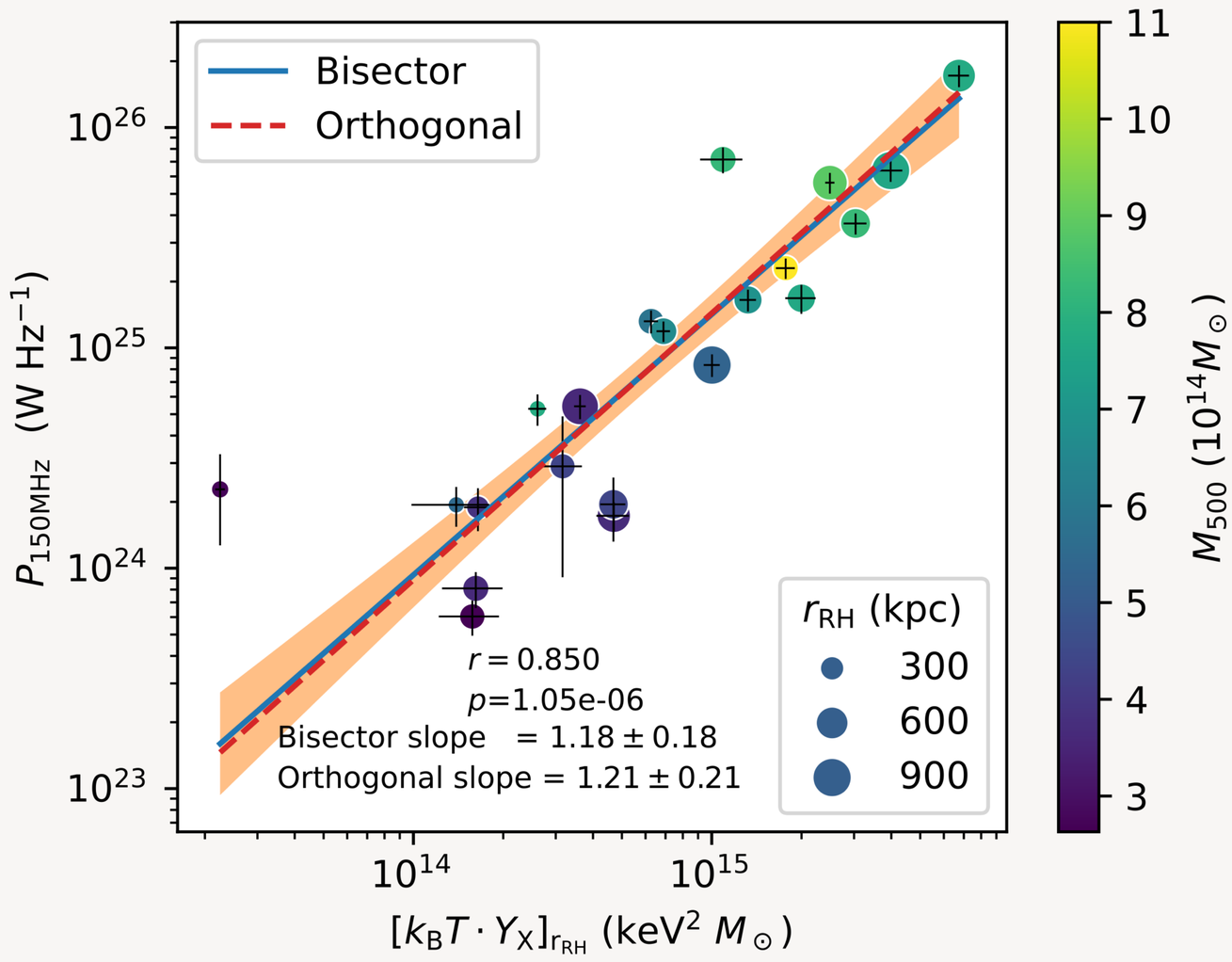
$P_{\mathrm{RH}} - [kT \times Y_{\mathrm{X}}]_{r_{\mathrm{RH}}}$ relation

- Sample: 21 deeply observed (XMM core-excised cts > 10000) radio halo clusters in LoTSS DR2 footprint
- Two determinants of radio halo power:
  1. Amount of thermal ICM within the radio halo volume
  2. ICM temperature



Turbulent acceleration scenario

Acceleration rate = Acceleration coefficient × Turbulent flux

$$\epsilon_{\mathrm{acc}} \equiv C_{\mathrm{acc}} \times \sigma_v^3 k \rho$$

- Resonant mechanisms, e.g., transit-time damping (Brunetti et al. 07 & 11)

$$C_{\mathrm{acc}} \propto \mathcal{M} c_{\mathrm{s}}$$

- Non-resonant mechanisms, e.g., adiabatic stochastic compression (Brunetti et al. 16 & 20)

$$C_{\mathrm{acc}} \propto \mathcal{M}^{-1} c_{\mathrm{s}}$$

➔

$$P_{\mathrm{RH}} \propto \int_{V_{\mathrm{RH}}} f(\mathcal{M}) c_{\mathrm{s}}^4 \rho \, \mathrm{d}V \propto f(\mathcal{M}) \left[T^2 M_{\mathrm{gas}}\right]_{r_{\mathrm{RH}}}$$

Ignoring the dependance of turbulent Mach number $f(\mathcal{M})$, the radio halo power at 150 MHz $P_{\mathrm{RH,150MHz}}$ has a tight correlation with $T^2 M_{\mathrm{gas}}$ (also known as TY_{X}) within the radio halo volume.

Publication:

- *The Planck clusters in the LOFAR sky. III. LoTSS-DR2: Dynamic states and density fluctuations of the intracluster medium,* **X. Zhang,** A. Simionescu, F. Gastaldello, D. Eckert, L. Camillini, R. Natale, M. Rossetti, G. Brunetti et al., A&A 672, A42 (2023)

Reference:

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