Inferring parameters of AGN jets using Bayesian analysis of VLBI data

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The model

Inhomogeneous jet model [1] is widely used to infer the parameters of AGN jets. It explains core spectra, frequency dependent core shift.

Assumptions:
- Cone ($\varphi_{core}$) geometry with speed $\Gamma=\text{const}$
- Magnetic field & particle density: $B = r^{-m}$, $K = r^{-n}$
- Emitting particles: $N(r) \propto r^{-m-1}$, $\pi \propto r^{-s}$ with $F_e \sim v^{-s}$
- Approximation of $\theta_{core}/\varphi_{core} \gg 1$

Conventional methods

Have to make assumptions to break the degeneracy, e.g.:
- equipartition [2]
- optically thick regime [3] - to make flux come into play

Why don’t just fit the model to the visibilities?

Params: $x$, $y$, $\theta_{core}$, $B_0$, $K_0$, $\Gamma$, $\theta_{jet}$, $\varphi_{core}$, $m$, $n$, $s$
Problem: multiple degeneracies
Solution:
- Reparameterization (speed up fitting)
- Constraining $\alpha$ (need # > 1 freqs).
- Constant magnetization $n=2m$ (coherent with BK assumption of cone shape) – minimal degeneracy-breaking assumption.

References:

Data used:
The conventional jet angle maps are from the AGN jets database maintained by the MIRIAD, since Lister et al., 2014, ApJ, 793, 27.

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“Fitting” the model

- We want posterior given data and priors.
- Data: 15.3 & 8.1 GHz VLBA obs. of radiogalaxy NGC315 [5]
- Priors: uniform (mostly in log-scale)

Left: Sampled posterior distribution of the parameters
Lower: MOJAVE [6] slice of $\alpha$ along a jet ridge line. Our fit gives $\alpha \approx [1.08, 1.03]$ (95% credible interval)

Conclusions

- Jet model [1] has internal degeneracies which can be minimally broken assuming constant magnetization and using multifrequency VLBI data.
- pc-scale jet of radiogalaxy NGC315 is well represented by inhomogeneous jet model [1].
- Further steps:
  - (analytically) accelerating collimating (parabolic) jet turning into constant speed cone jet,
  - (numerically) treatment of small angles and stratification structure, MHD simulations as input.