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 (φ_{open}) geometry with speed Γ=const
- Magnetic field & paticle density: $B \sim r^{-m}$, $K \sim r^{-n}$
- Emitting particles: $N(\gamma)=K\gamma^{-s}$, $\alpha=(s-1)/2$ with $F_\nu \sim \nu^{-\alpha}$
- Approximation of $\theta_{LOS}/\varphi_{open} >> 1$

Conventional methods

Have to make assumptions to break the degeneracy, e.g.:

- equipartition [2]
- optically thick regime [3] - to make flux come into play

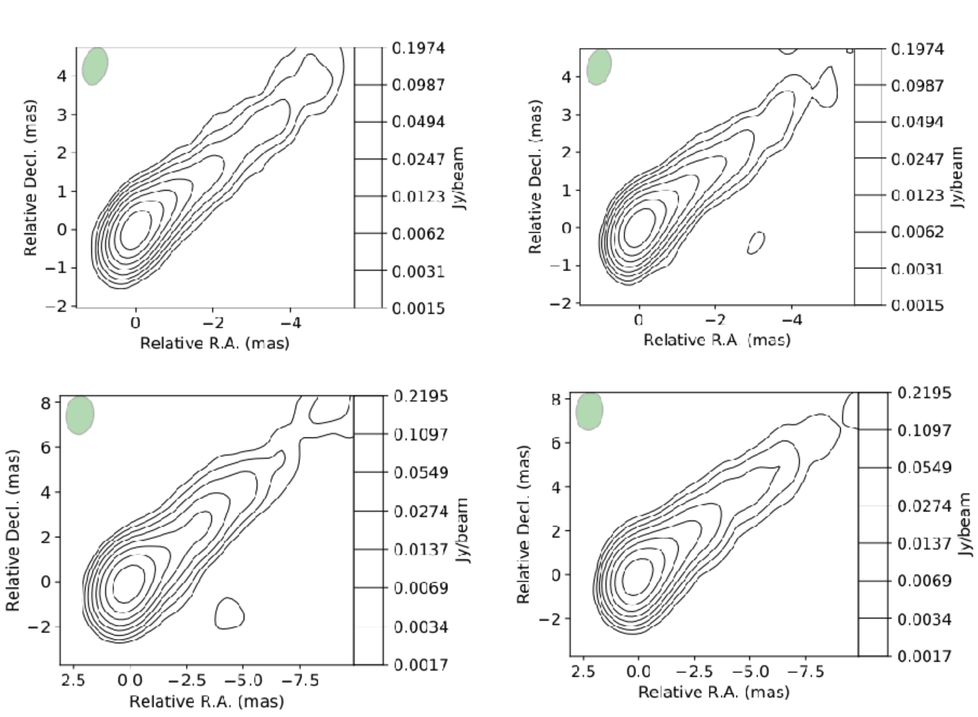
Why don't just fit the model to the visibilities?

Params: x_0, y_0, θ_{rot}, B_1, K_1, Γ, θ_{LOS}, φ_{open}, m, n, s

Problem: multiple degeneracies

Solultion:

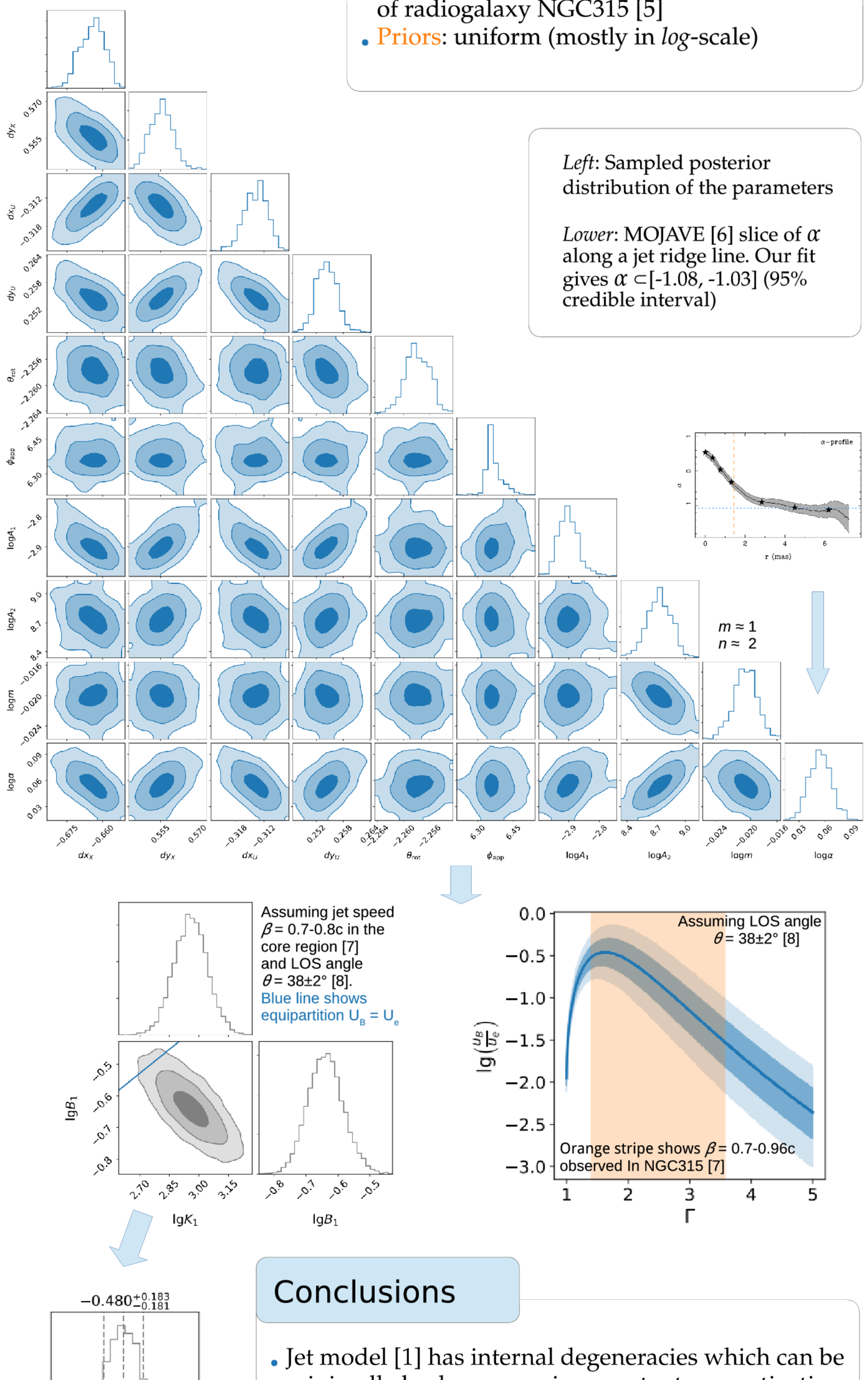
- Reparameterization (speed up fitting)
- Constraining α (need # > 1 freqs).
- Constant magnetization $n=2m$ (coherent with BK assumption of cone shape) – *minimal degeneracy-breaking* assumption.



Upper: Stokes I map of NGC315 at 15.3 (*Up*) and 8.1 GHz (*Low*) epoch 2006-02-12.
Real observation (*Left*) and our simulated data (*Right*).

"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 α along a jet ridge line. Our fit gives $\alpha \subset$[-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.

References:

1. Blandford, R. D.; Königl, A., AJ 232, p.34, 1979
2. Lobanov A. P., A&A 330, p.79, 1998
3. Zdziarski A.A., Sikora M. *et al.*, MNRAS 451, p.927, 2015
4. https://github.com/kbarbary/nestle & dfm/emcee
5. Lister M.L., Aller H.D. *et al.*, AJ 137, p.3718, 2009
6. Pushkarev A.B., Hovatta T. *et al.*, A&A 545, A113, 2012
7. Cotton W.D., Feretti L. *et al.*, ApJ 519, p.108, 1999
8. Canvin J.R., Laing R.A. *et al.*, MNRAS 363, p.1223, 2005

Data used:

This research has made use of data from the MOJAVE Database that is maintained by the MOJAVE team (Lister et al., 2009, AJ, 137, 3718)

Acknowledgements:

This work is supported by Russian Science Foundation grant 16-12-10481.