Quasar Structure Effects on the VLBI Reference Frame

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Outline

① Quasar structure

② Case study: 1144 – 379
Improving the reference frame

✧ What you look at
  ⊛ Are quasars point-like?
  ⊛ Quasar structure → position errors

✧ How you look at it
  ⊛ Atmospheric effects
  ⊛ Long baselines = worse solutions
International VLBI Service

N > 20

N = 4 + 3
Southern Quasars

North Celestial Pole

South Celestial Pole
Quasars

What you want them to be
✧ Bright point sources
✧ Fixed in space and time

What they are
✧ Supermassive black holes
✧ Jets and outflows ➔ structure
✧ Evolving on all timescales
Southern quasar variability: 1144 - 379

✧ UTas Ceduna 30m telescope
✧ Single dish flux density monitoring
✧ Highly variable over weeks!

✧ Core + jet

Range: 7 months
Range: 8 years

Source brightness / Jy

Jan '04 Jan '07 Jan '10

Core position ≠ Source position

Image: Ojha et al. 2010

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Southern quasar variability: 1144 - 379

✧ UTas Ceduna 30m telescope
  ✧ Single dish flux density monitoring
  ✧ Highly variable over weeks!

✧ Excluding 1144-379 improves OCCAM solutions for station positions

Source brightness / Jy

Range: 7 months
Jan '04
Jan '07
Jan '10

Range: 8 years

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Geodetic source positions

20 μas = SI 2
60 μas = SI 3
200 μas = SI 4

good
worse
awful
OCCAM can correct offset in 1057-797 position

→ Source structure in 1144-379

Different centroid for each baseline
Can we predict whether a quasar will misbehave?
Flux density monitoring

![Graph showing new flares](6.7\ GHz)

New flares
Flux density monitoring
Frequency dependence
Frequency dependence

New flares

High ➔ low frequencies
Minimizing quasar effects

1. Structure: minimum flux density state
2. Ionosphere: need same structure at S and X
Predicted stability

A diagram showing the predicted stability over time with MJD (Modified Julian Date) on the x-axis and Flux (Jy) on the y-axis. The chart compares 2.3 GHz and 8.4 GHz signals, with markers indicating different stability conditions:

- **Bad**: X jet < max, S jet < max
- **Better?**: X jet max, S jet < max
- **Best**: X core, S core

The diagram suggests a comparison of different stability levels and their transitions over time.
Predicted stability

**Test:** OCCAM source position offsets
Observed stability
Observed stability

Predict solution quality!
Summary

✧ Choice of quasars important
✧ **Frequency dependence** of source structure
✧ Quality control:
  ✧ Multi-frequency flux density monitoring
  ✧ IVS amplitude calibration
  ➔ Quasar stability during an observation

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