Interferometric Dreams of an Extragalactic Astronomer

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VLT Interferometry
Encouragement:
How Dreams have Become True

Some lessons from the history of Radio Interferometry

1948: Use the sea as reflector

1997: VLBA image
The first revolution in interferometry

For example: Cygnus A
Interferometry at Infrared Wavelengths (1.2 to 20 µm)

Example: VLTI

- Primary beam: \( B = 1.2 \frac{\lambda}{D_{tel}} \)
- Interferometric beam: \( b = \frac{\lambda}{d_{ij}} \)
- Ideal situation:
Interferometry at Infrared Wavelengths (1.2 to 20 µm)

VLTI imaging:

- Phase closure (≥3 telescopes - AMBER)
- External phase reference (Fringe tracker on PS)
- VLTI uv coverage:

\[ \delta = -15^\circ \]

\[ \lambda = 2 \text{ m} \]

\[ b = 8 \text{ mas} \]

\[ 4 \text{ mas} \]
Dreaming Realistically
(and some wilder dreams)

A. VLTI, full imaging, full AO at $\lambda \geq 1.6 \, \mu m$

<table>
<thead>
<tr>
<th></th>
<th>B (mas)</th>
<th>b (mas)</th>
<th>auto</th>
<th>1h, 10$\sigma$</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMBER 2$\mu$m</td>
<td>60</td>
<td>4</td>
<td>10 mJy</td>
<td>0.1 mJy</td>
</tr>
<tr>
<td>MIDI 10$\mu$m</td>
<td>300</td>
<td>20</td>
<td>400 mJy</td>
<td>10 mJy</td>
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B. XVLTI, fiber-linked, heterodyne?
My Current Dreams:

- **Dream I:** Detect and investigate the dusty tori in AGNs
- **Dream II:** Witness the formation of radio jets
- **Dream III:** Resolve the BLR in nearby AGNs
- **Dream IV:** Measure proper motion of nearby galaxies
Dream I: Dusty Tori in AGNs

What do we expect?
Dream I: Dusty Tori in AGNs

What do we want to know?

**Seyfert I galaxies:**

- Size of the torus
- Inner diameter
- Temperature distribution
- Fine structure - clumps?

[Diagram of a dusty torus with dimensions labeled: 10 pc and 10 µm]
Dream I: Dusty Tori in AGNs

What do we want to know?

Seyfert II galaxies:

- Orientation of torus - Unification?
- Inner diameter
- Temperature distribution
- $\tau(\lambda, r)$: SiO/continuum

Seyfert II galaxies: 12pc, 10 µm
Dusty Tori in AGNs

The next steps with MIDI: 2003 ... 2006

- Size as function of $\lambda$
- Orientation of torus
- Fine - structure?

E.g. Seyfert II galaxy
Dream II: Witnessing the Formation of Radio Jets

What do we expect?

Requirements

Resolution:  < 10 mas
Sensitivity:  ~ 0.5 mJy
Dynamic range:  > 125:1

VLTI 2µm

VLBA 2cm Survey

30mas

2 cm
The Formation of Radio Jets

What do we want to see?

- Detect a VLBI knot!
- Determine spectrum
- Proper motion
- Spectral evolution

![Diagram showing radio jets with annotations and measurements like 2 cm and 30 mas.]
Dream III: Resolve the BLR in nearby AGNs

What do we expect?

Requirements:

- Resolution: 100 µas at 2 µm
- Spectral lines: $P_\beta$ & $Br_\alpha$

140 µas at $z = 0.01$
Dream IV: Proper motions in nearby galaxies

What do we expect?

Requirements:

• Dual Beam (PRIMA)
• Astrometry to < 50 μas
• Reference star \( m < 15 \)
• Known PM of reference: SIM - GAIA - quasars
Summary

On the morning after ...

- **VLTI with current instruments** *(MIDI, AMBER, PRIMA)*: Dusty tori *(5…10)*, radio jets *(1…3)*, proper motions (?)

- **VLTI with next generation** *(better sensitivity, imaging)*: Dusty tori *(50)*, radio jets *(10)*, proper motions *(many)*

- **Beyond VLTI [XVLTI] (3 – 10 km, heterodyne, ...)**: Dusty tori *(z = 0.3)*, radio jets *(z = 1)*, BLRs in AGNs, proper motions *(Virgo)*