Radio lobes of microquasars

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Large-scale structure of jets

- Jets inflate lobes
- Filled with magnetic fields and relativistic electrons
- Radio synchrotron emission

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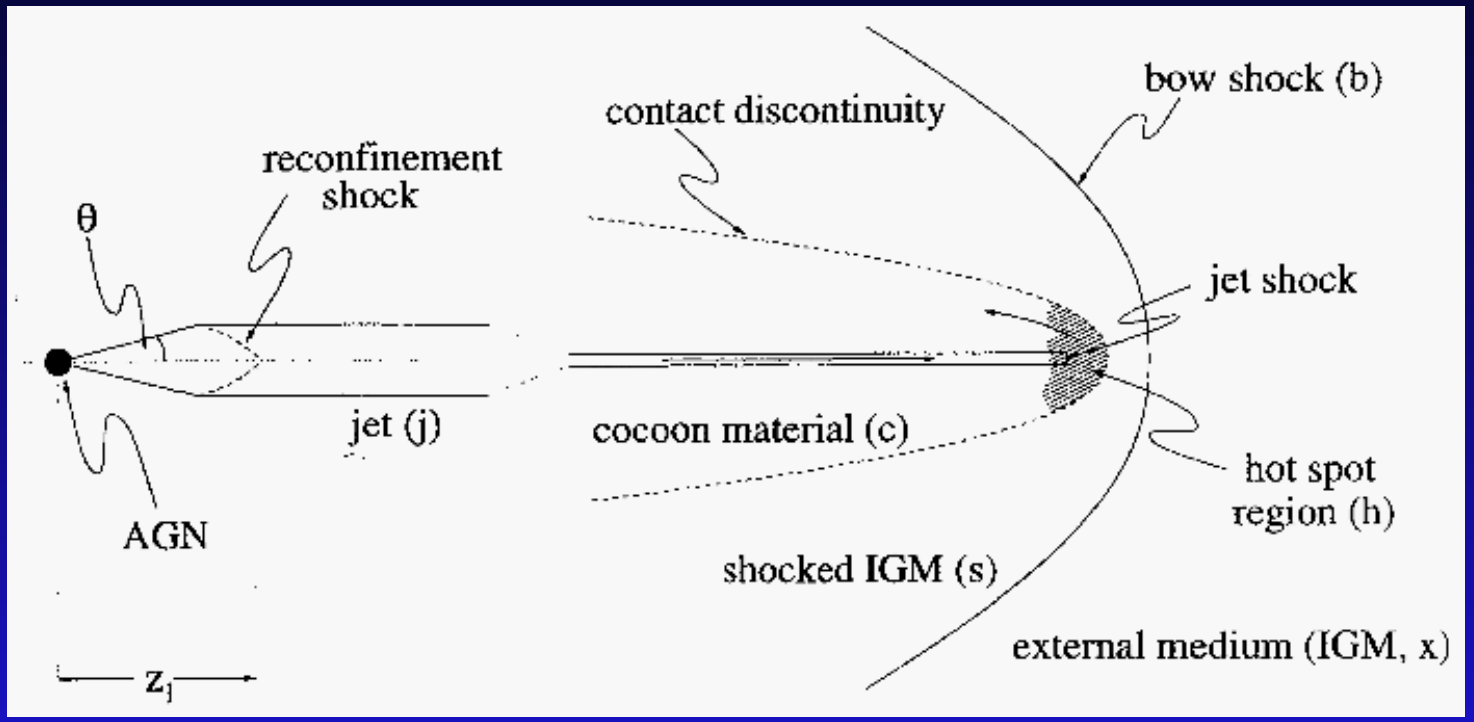
Large-scale structure of jets



(Kaiser & Alexander 1997)

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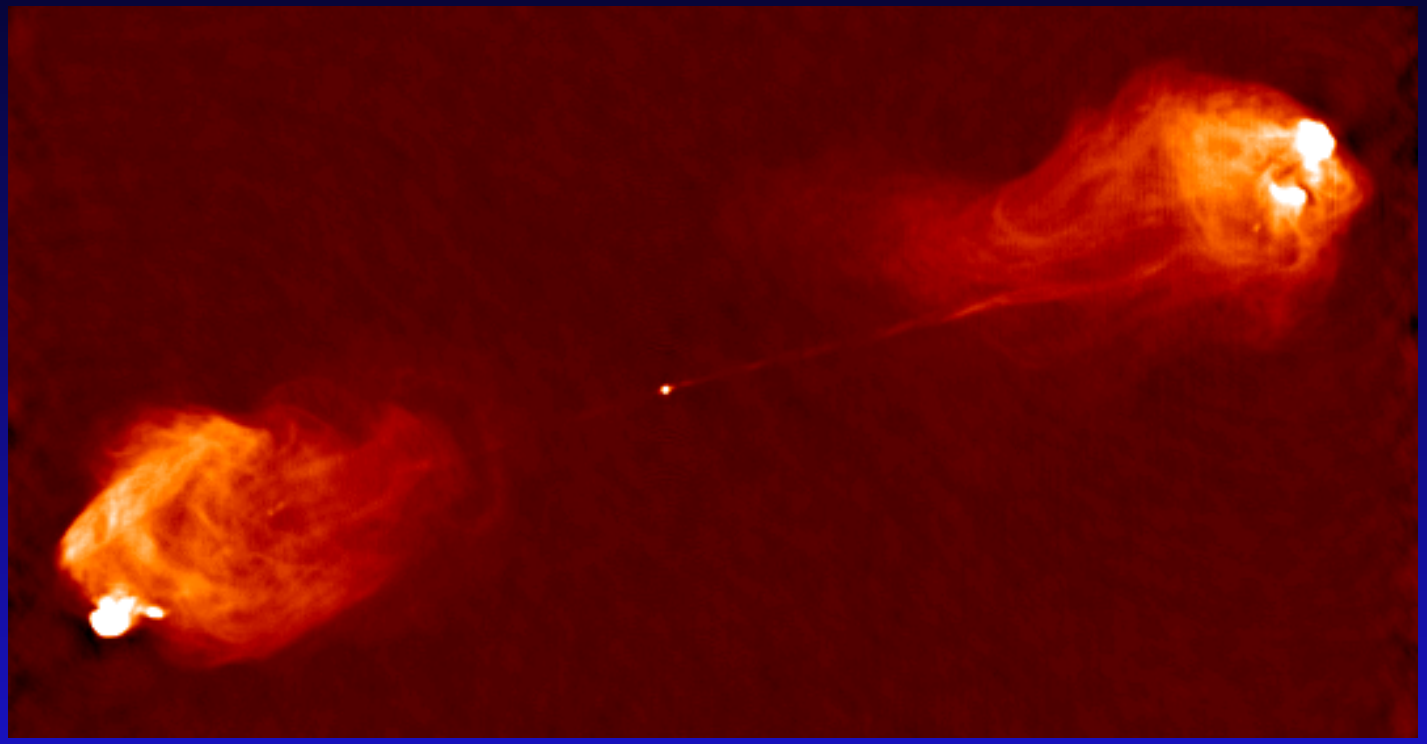
Large-scale structure of jets



(NRAO)

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Why bother?

- Lobes constrain the ‘integrated history’ of jets
- Constrain jet physics
- Constrain environment density

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Radio luminosity of lobes

- Theoretical scaling with black hole mass (Heinz 2002)

$$L_n \mu M^{1.3®1.7}$$

- Observations (Lacy et al. 2001)

$$L_n \mu M^{1.9}$$

- But: at low luminosities, no scaling found by Best et al. (2005)

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Microquasar lobes

- Microquasars in low density environment
- Fast expansion
- Low luminosity
- …but not too low: Same predicted radio flux as radio galaxy 100s of Mpc away.
- Should be detectable

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Microquasar lobes

- Some are happily detected:

(SS433, Dubner et al. 1998)

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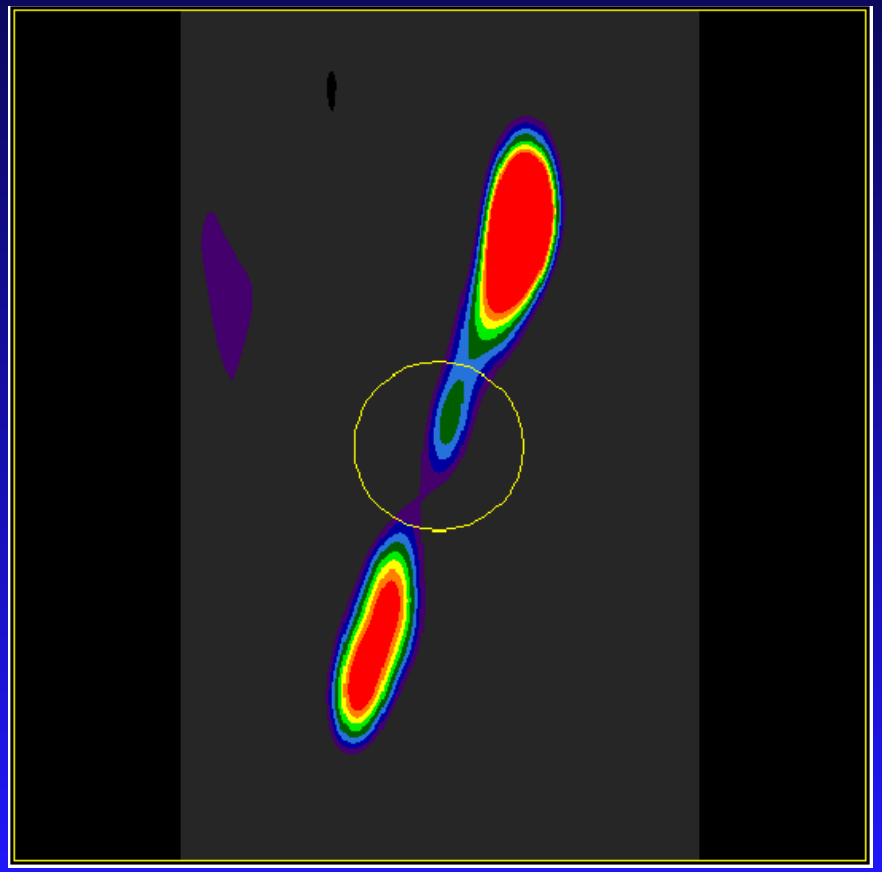
Microquasar lobes

- Some are happily detected:



(1E 1740.7-2942,
Mirabel et al. 1993)

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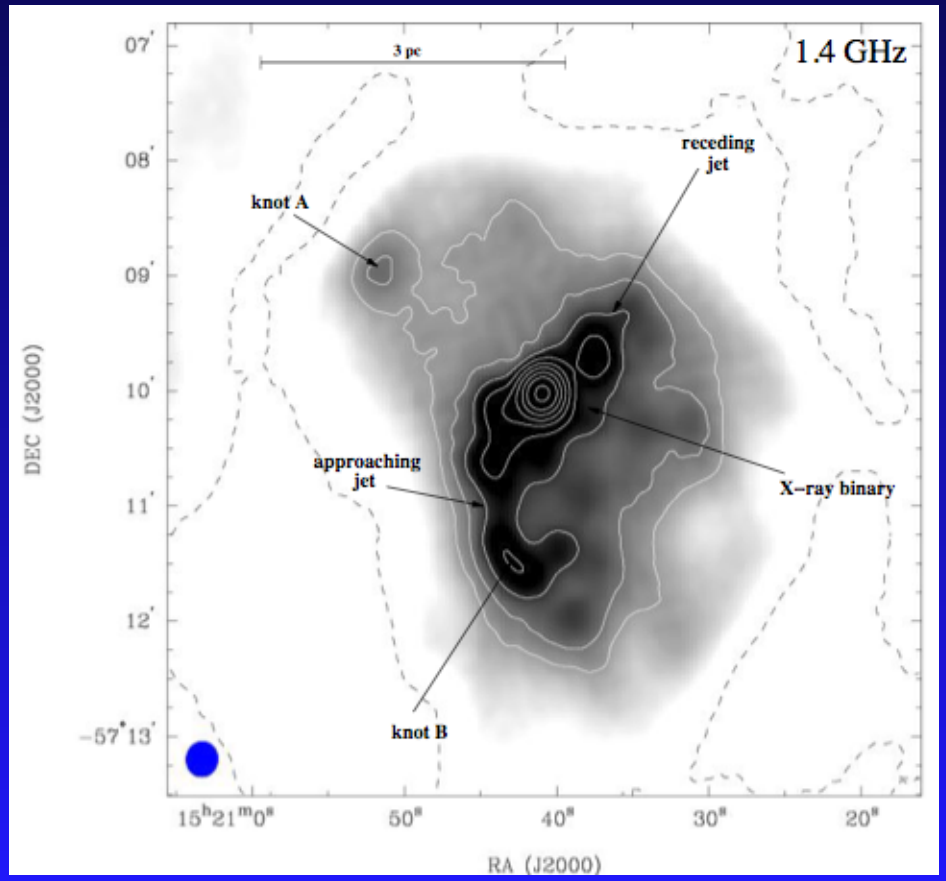
Microquasar lobes

- Some are happily detected:



(Cir X-1, Tudose et al. 2006)

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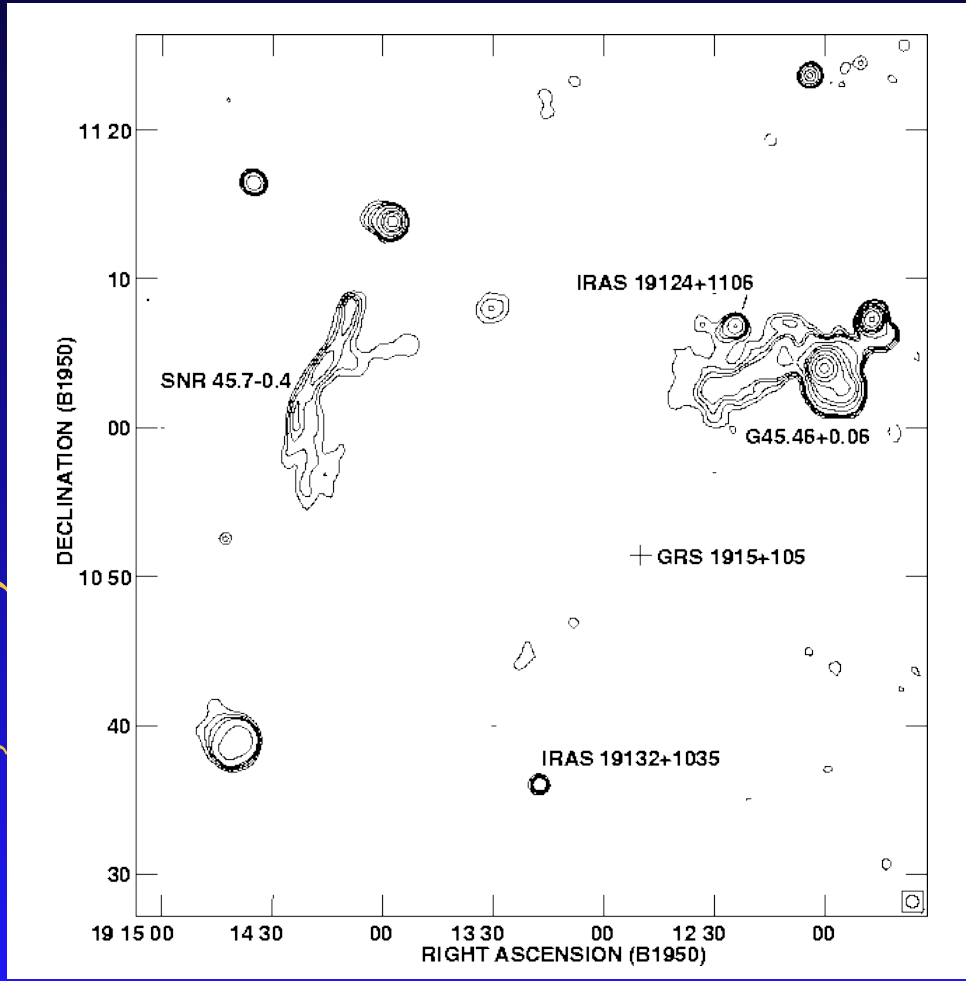
Microquasar lobes

- Others are not:

(GRS 1915+105, Rodríguez & Mirabel, 1999)



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Microquasar lobes

- What's the problem?
- Inefficient particle acceleration (low density environment)?
- Little energy in magnetic field and/or particles?
- Lobes brighter at lower frequencies.

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Other techniques

- Lobe expansion compresses and partially ionises ISM.
- Radio bremsstrahlung
- Optical emission lines

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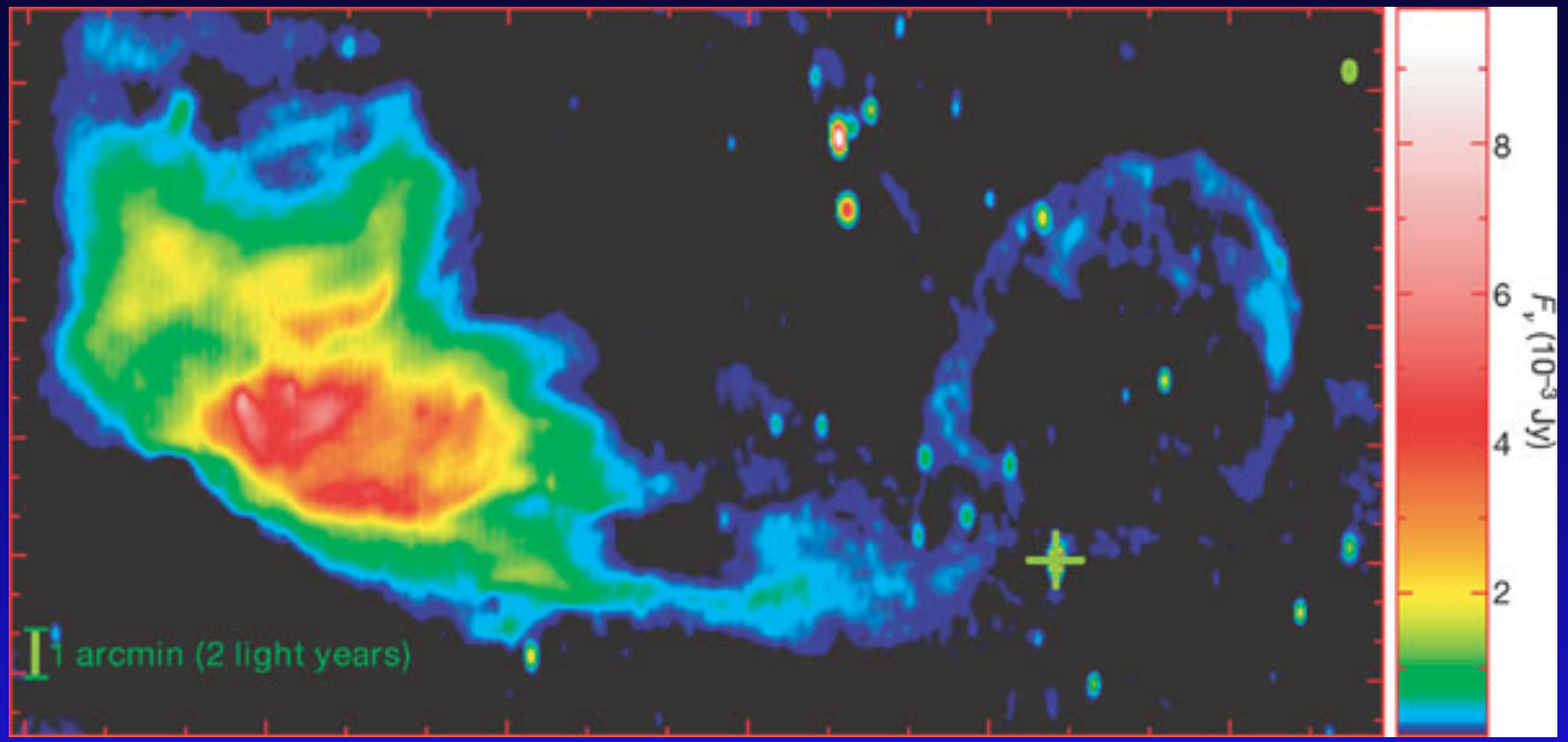
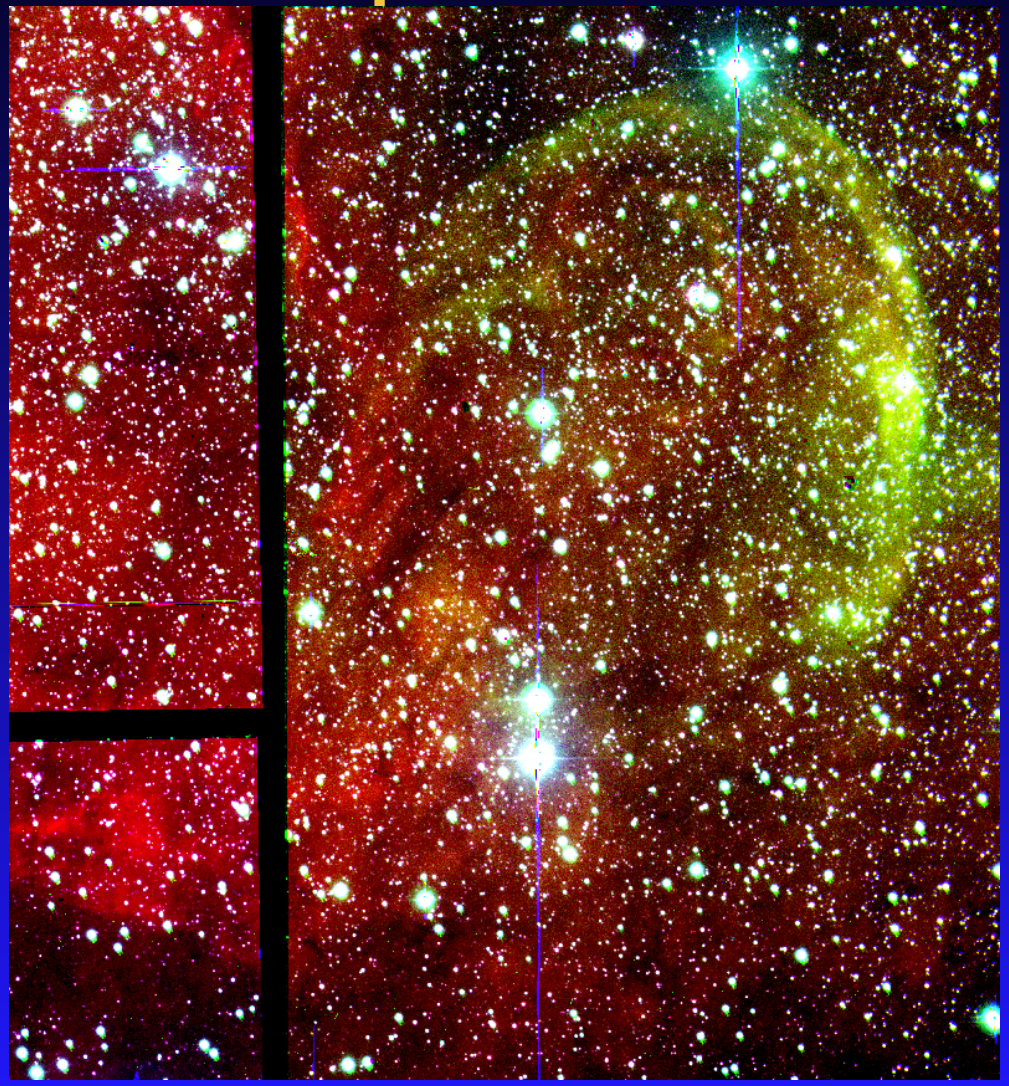
Other techniques



(Cyg X-1, Gallo et al., 2005)

Other techniques

- Hα and OIII emission:



(Russell et al., 2007)

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Early results

- Lobe detection constrains:
  - Density of environment
  - Source age
  - Time-averaged jet power
- Cyg X-1 lobe requires 100 times more powerful jet than currently observed
- Large ‘dark’ content?

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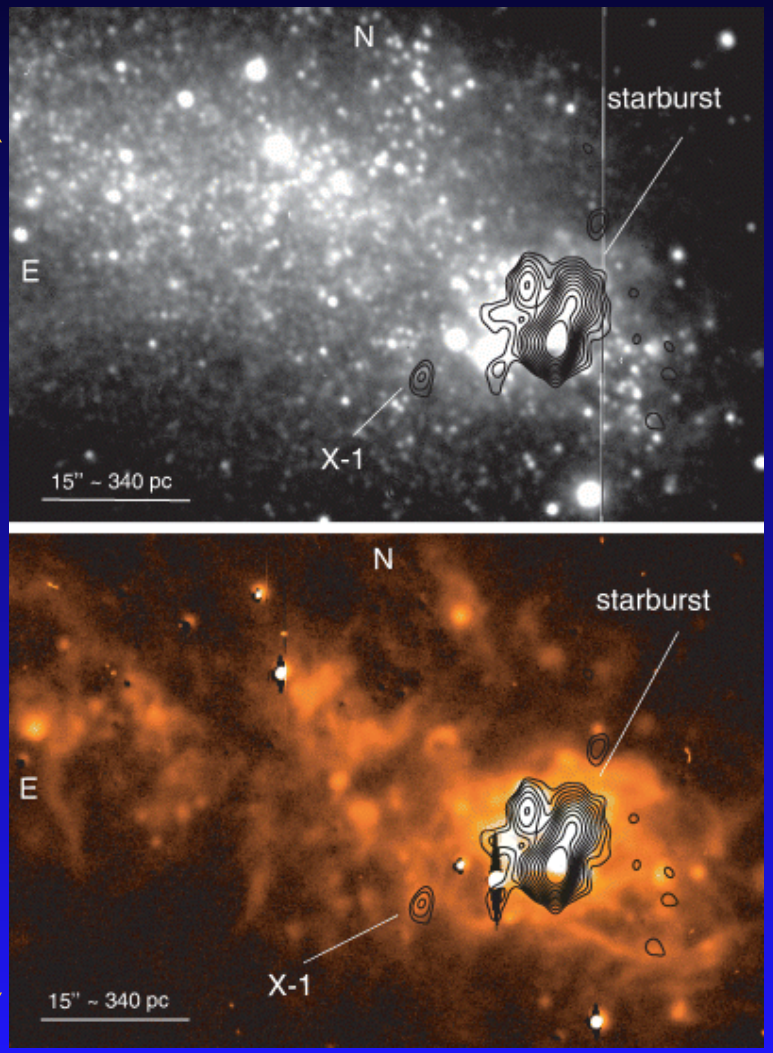
ULX

- Finding radio lobes in other galaxies:



(NGC 5408 X-1, Soria et al. 2006)

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- Typical size expected ~ 100 pc
- At 10 Mpc ~ 1”
- Requires international baselines for LOFAR
- Flux hopefully not a problem with 0.3 mJy at 4.8 GHz

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Summary

- Jet inflated lobes give ‘integrated history’ and shock physics of microquasars
- For synchrotron lobes the lower the frequency, the better
- For bremsstrahlung low frequencies don’t hurt
- Need long baselines for identification in other galaxies

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