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
Large-scale structure of jets

(Kaiser & Alexander 1997)
Large-scale structure of jets

(NRAO)
Why bother?

• Lobes constrain the ‘integrated history’ of jets
• Constrain jet physics
• Constrain environment density
Radio luminosity of lobes

- Theoretical scaling with black hole mass (Heinz 2002)
  \[ L_n \propto M^{1.3 \pm 1.7} \]

- Observations (Lacy et al. 2001)
  \[ L_n \propto M^{1.9} \]

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

- Some are happily detected: (SS433, Dubner et al. 1998)
Microquasar lobes

- Some are happily detected:
  - (1E 1740.7-2942, Mirabel et al. 1993)
Microquasar lobes

- Some are happily detected:

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

- Others are not: (GRS 1915+105, Rodríguez & Mirabel, 1999)
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.
Other techniques

• Lobe expansion compresses and partially ionises ISM.
• Radio bremsstrahlung
• Optical emission lines
Other techniques

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

- Hα and OIII emission:

(Russell et al., 2007)
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?
ULX

- Finding radio lobes in other galaxies:

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

- 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
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