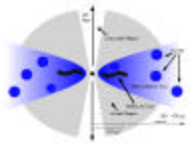



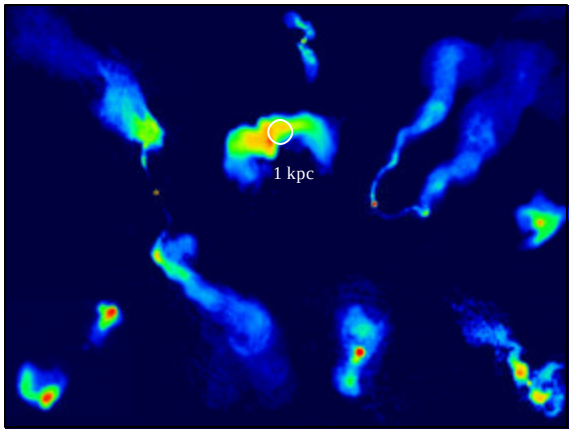

The Environs of Massive Black Holes and Their Relativistic Jets

Greg Taylor
NRAO
Albuquerque AAS, 2002 June 5

The Very Long Baseline Array (VLBA)

Why we care about the environment:

- a black hole alone does not make for an AGN
- what are the fueling rates and fueling mechanisms?
- how is the jet collimated?
- what is the ambient magnetic field strength & topology?
- environment plays a key role in unified schemes
- investigate torus chemistry and physics
- Disturbed morphologies may indicate interactions with surrounding gas
- look for inflows/outflows
- use gas kinematics to weigh the central engine



Hydra A

Taylor (1996)

core:

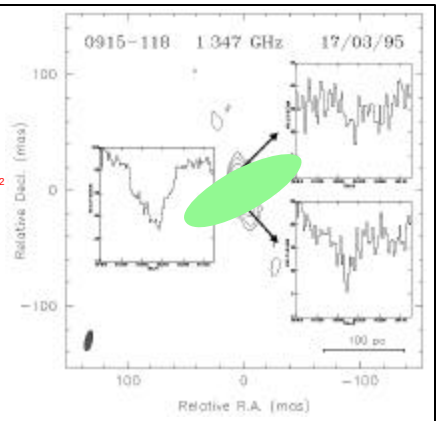
$\tau \sim 0.8$

FWHM = 80 km/s

$N_H = 1 \times 10^{24}$ cm^{-2}

for $T_{spin} = 8000$ K

$M \sim 2 \times 10^7 M_{sun}$
for r=50 pc



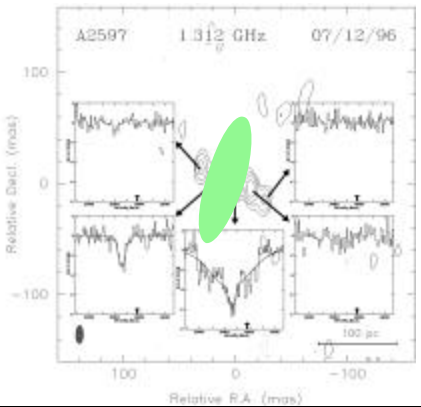
HI absorption in PKS 2322-123

Taylor et al. (2000)

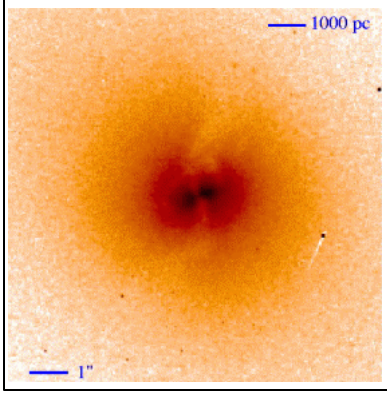
core:

$\tau \sim 0.26$
FWHM = 735 km/s
$N_H = 3 \times 10^{24}$ cm^{-2}
for $T_{spin} = 8000$ K

$M \sim 10^9 M_{sun}$
for r=50 pc

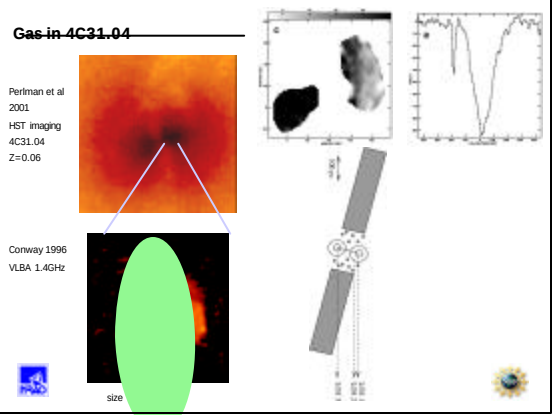


Gas in 4C31.04



Perlman et al
2001
HST imaging
4C31.04
Z=0.06

Gas in 4C31.04



HI absorption in 1946+708

Peck & Taylor (2001)

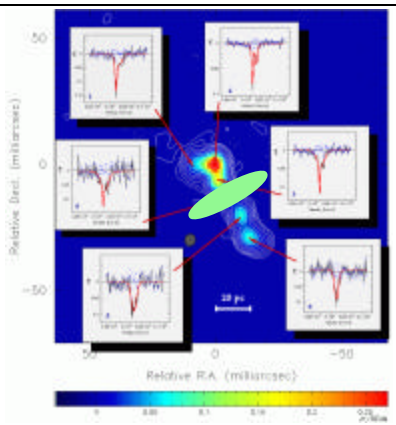
"Global" VLBI observations

core:

$\tau \sim 0.2$
FWHM = 350 km/s
$N_H = 3 \times 10^{23}$ cm^{-2}

for T_{spin} = 8000 K

$M \sim 10^8 M_{sun}$

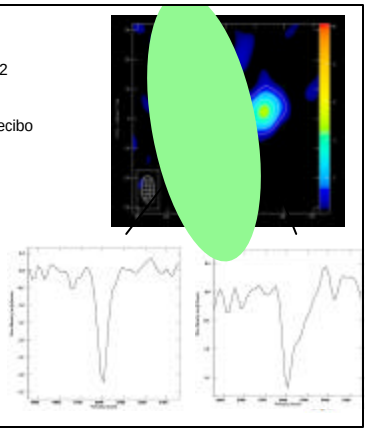


NGC 7674

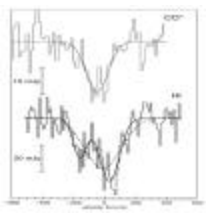
Momjian et al 2002

Poster 45.10

VLBA + Y27 + Arecibo



Cygnus A



Fuente et al 2001, Conway & Blanco 1995

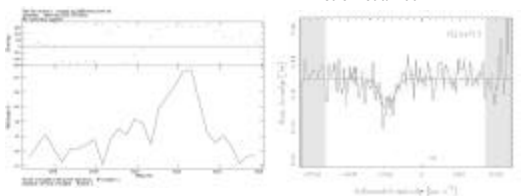
- HI absorption consistent with a 50pc radius torus
  (Conway & Blanco 1995).
- Molecular counterpart has been searched for in CO(115GHz), H_2CO (4.8GHz), OH (1.6GHz) but not detected
  (Conway & Blanco 1995, Barvainis & Antonucci 1994).

Why no CO?

1. Gas pressure not high enough to keep gas molecular.
2. No molecules survive in the lower energy levels.

1323+321 6.03 GHz OH

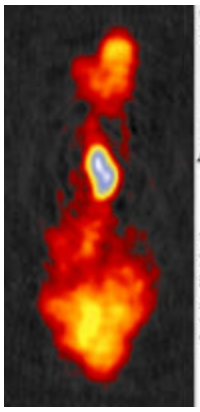
Pihlström et al 2002



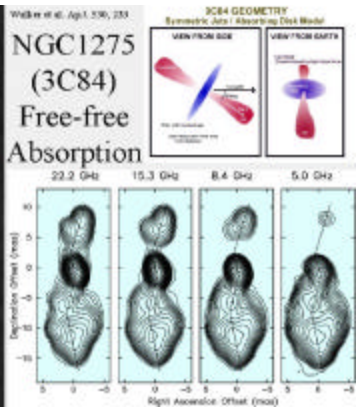
VLA 5GHz observations:

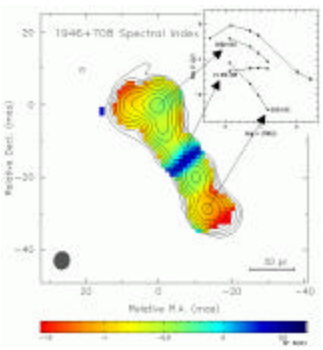
HI and 6.03 GHz OH detected at the same velocity in the CSS 1323+321

Similar opacities ~ 0.002



NGC1275
(3C84)
Free-free
Absorption





Free-free absorption in 1946+708

Peck & Taylor (2001)

Spectral index map from 1.3/5 GHz VLBI observations

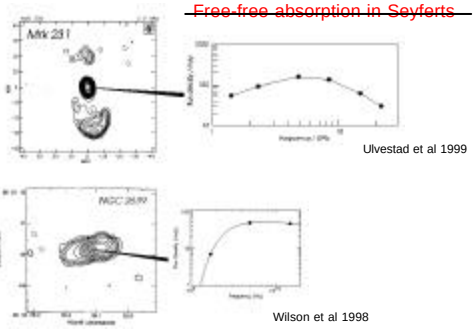
free-free optical depth:

$\tau_{ff} \sim T^{-3/2} n_e^2 \nu^{-2} d$

$N_e \sim 3 \times 10^{22}$ cm^{-2}

ionization ~ 10%

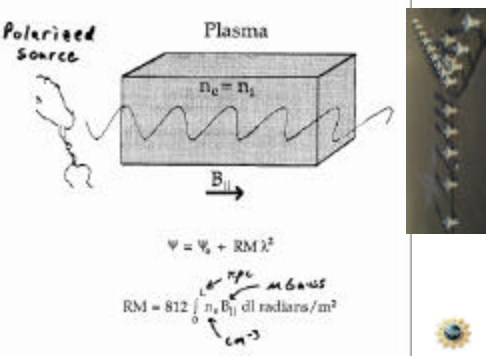
Free-free absorption in Seyferts



Ulvestad et al 1999

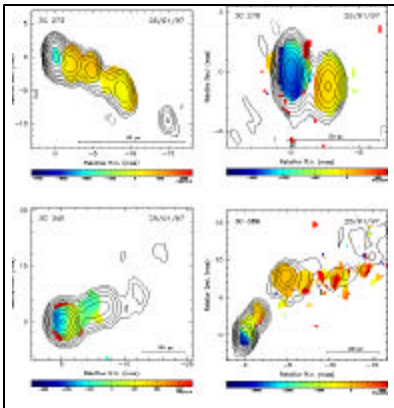
Wilson et al 1998

Faraday Rotation



$\Psi = \Psi_0 + RM\,\lambda^2$

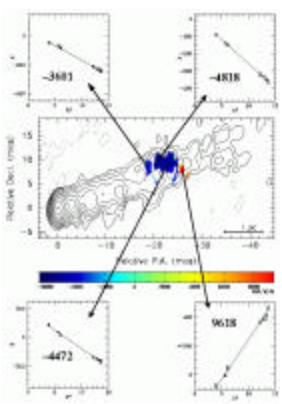
$RM = 812 \int_0^L n_e B_{||}\, dl$ radians/m^2



Taylor (1998)

Quasars:
3C273 RM = -1900
3C279 RM = -1280
3C345 RM = -130
3C380 RM = -2220

B = 0.1 μG if scales of order 10 pc and densities 10^4 cm^{-3}

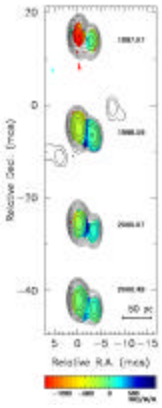


M87 Zavala & Taylor 2002

scale ~ 0.3 pc

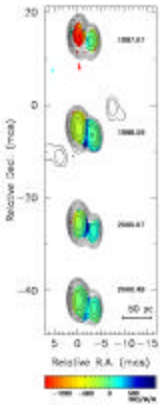
$n_e = 10^3$ cm^{-3}

B ~ 30 μG



Zavala & Taylor (2002)
AAS Poster 45.03

3C279 Rotation Measures changing in time

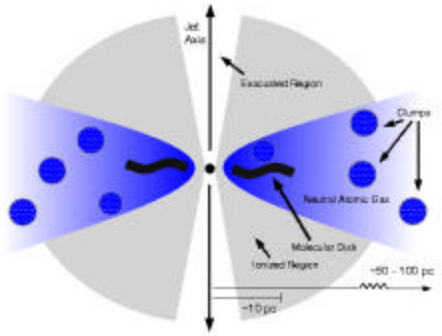


Zavala & Taylor (2002)
AAS Poster 45.03

Source

Screen

Observer



Summary of Methods
for Exploring the AGN Environment
on the parsec scale

- Atomic Gas
  - HI absorption
- Molecular Gas
  - Masers
  - Molecular gas in absorption
- Ionized Gas
  - free-free absorption
  - Faraday Rotation Measures