Relativistic Jets "at the Braking Point" in Radio Galaxies

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The Very Large Array (VLA)

- 27 25-meter antennas in Y-configuration
- Operated by NRAO in New Mexico
- Images radio sky at cm wavelengths

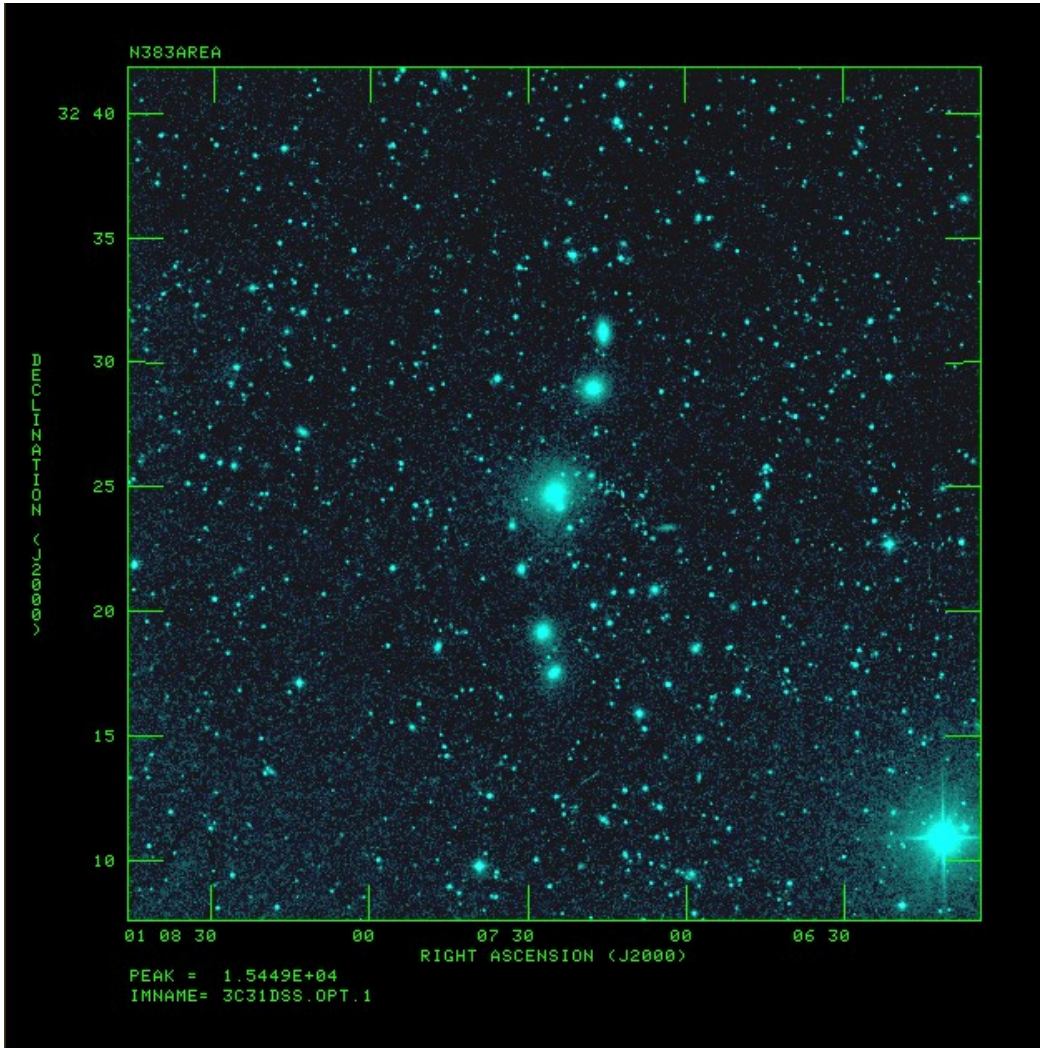
What the VLA does …

In the movies ("Contact")

In the real world

NGC383 Environs

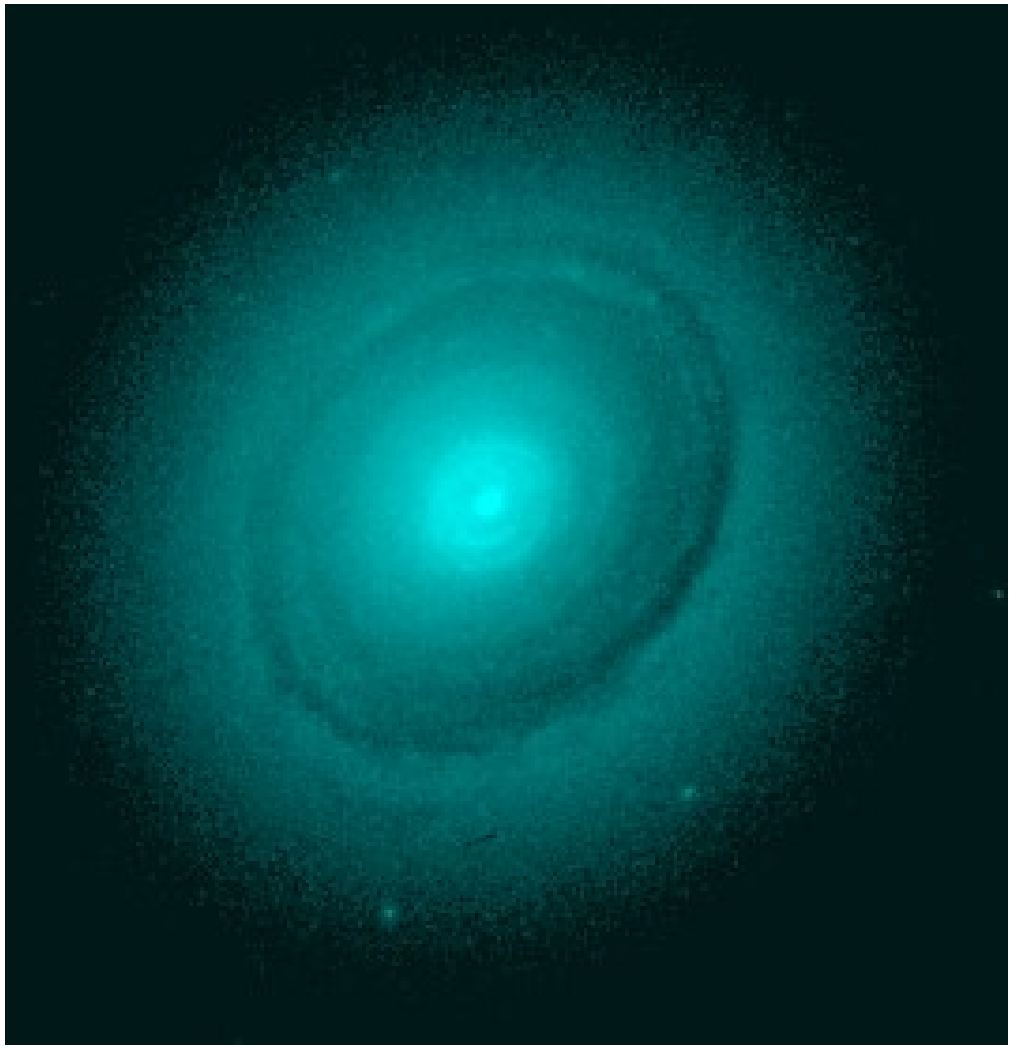
- Brightest galaxy in small chain
- in Perseus-Pisces filament
- one close companion



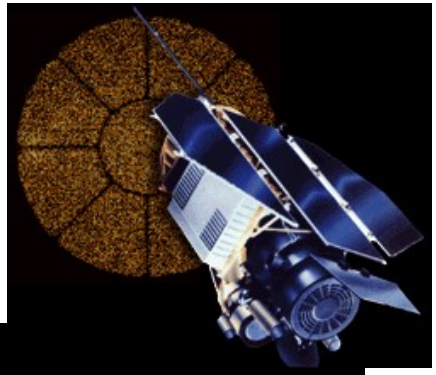
Approx 700 kpc field, Digitized Sky Survey E plate

NGC383

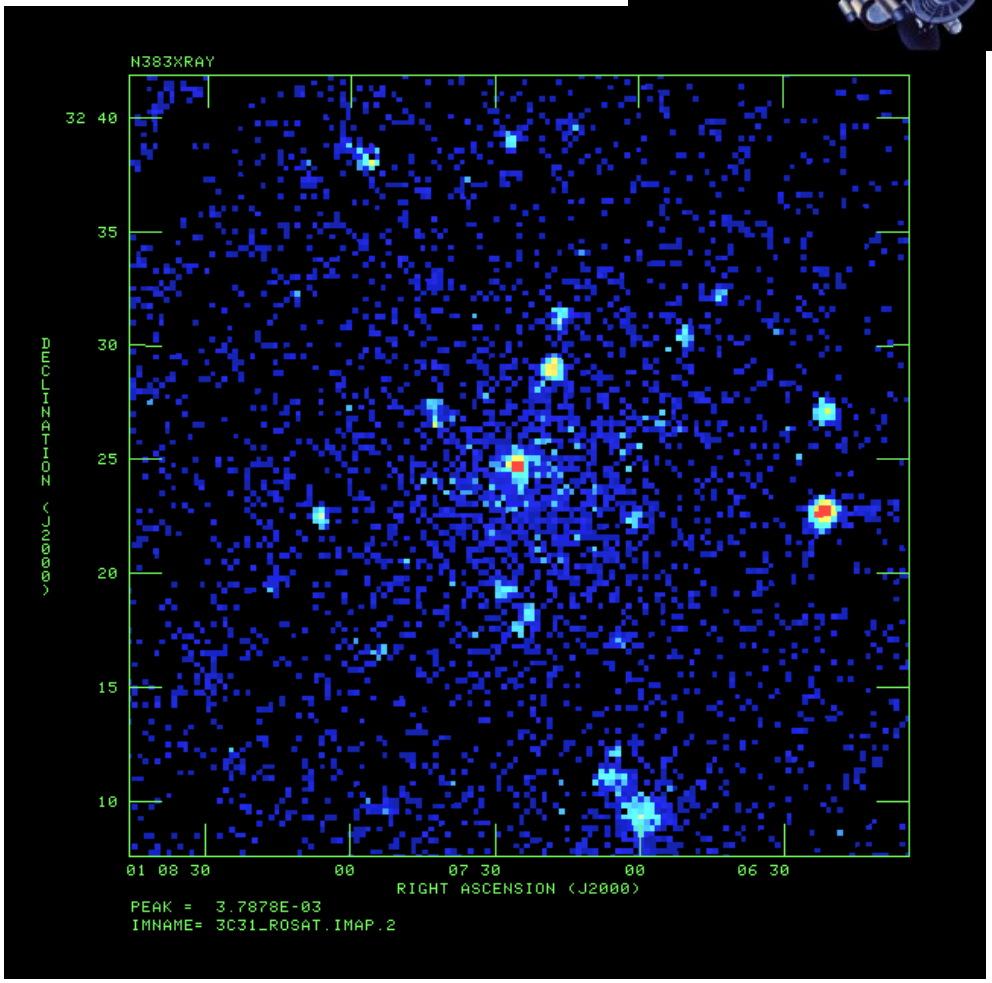
- dusty elliptical galaxy
- z=0.0167
- D=72 Mpc
- major axis of dust "disk" about 2.5 kpc



NGC383 Group Hot Gas

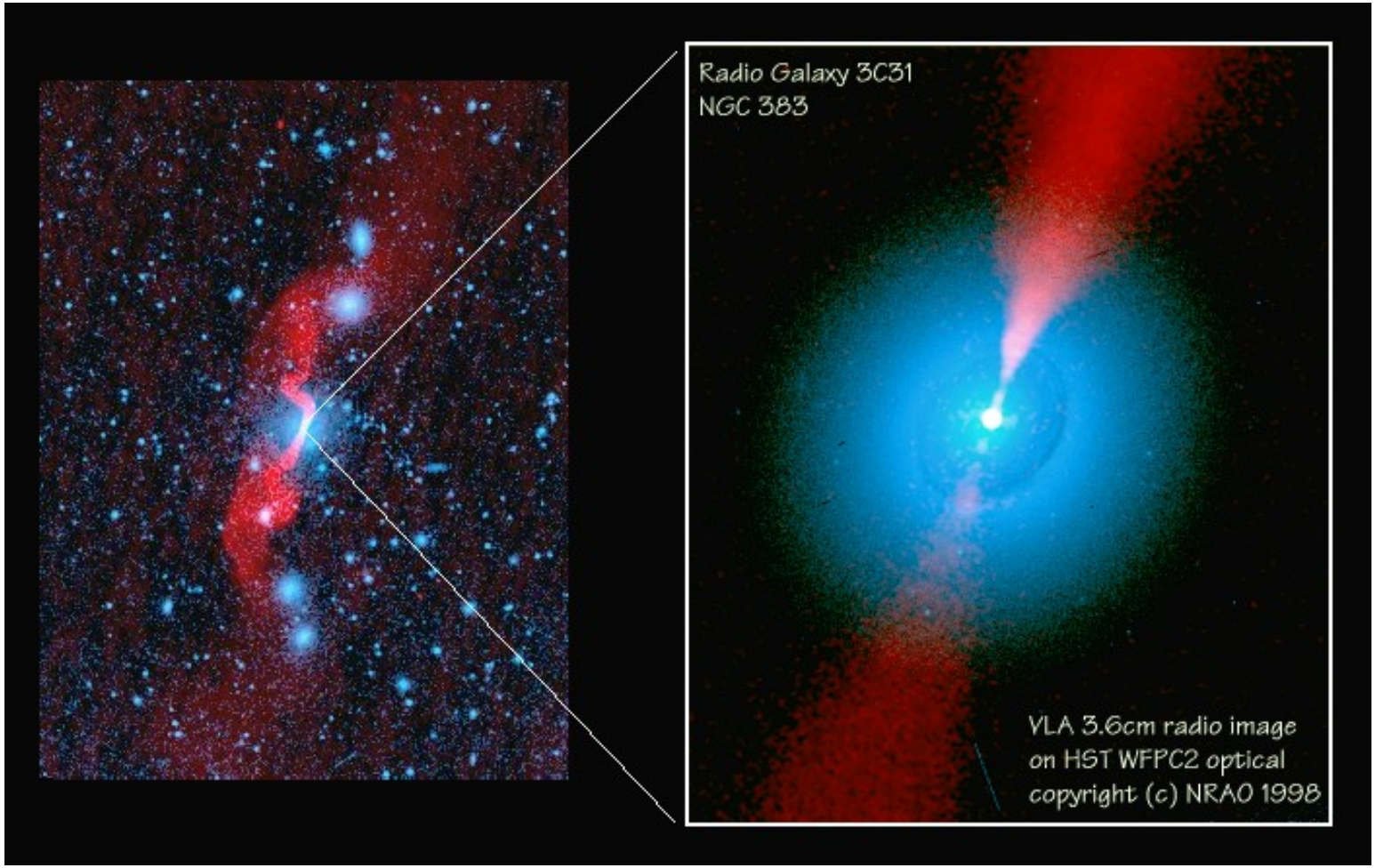


- Extended X-ray emission offset from NGC383
- →Hot (1.7 x 10^7K) group atmosphere
- Also more compact X-ray emission at NGC383 itself



Approx 700 kpc field, ROSAT PSPC image

Radio source 3C31

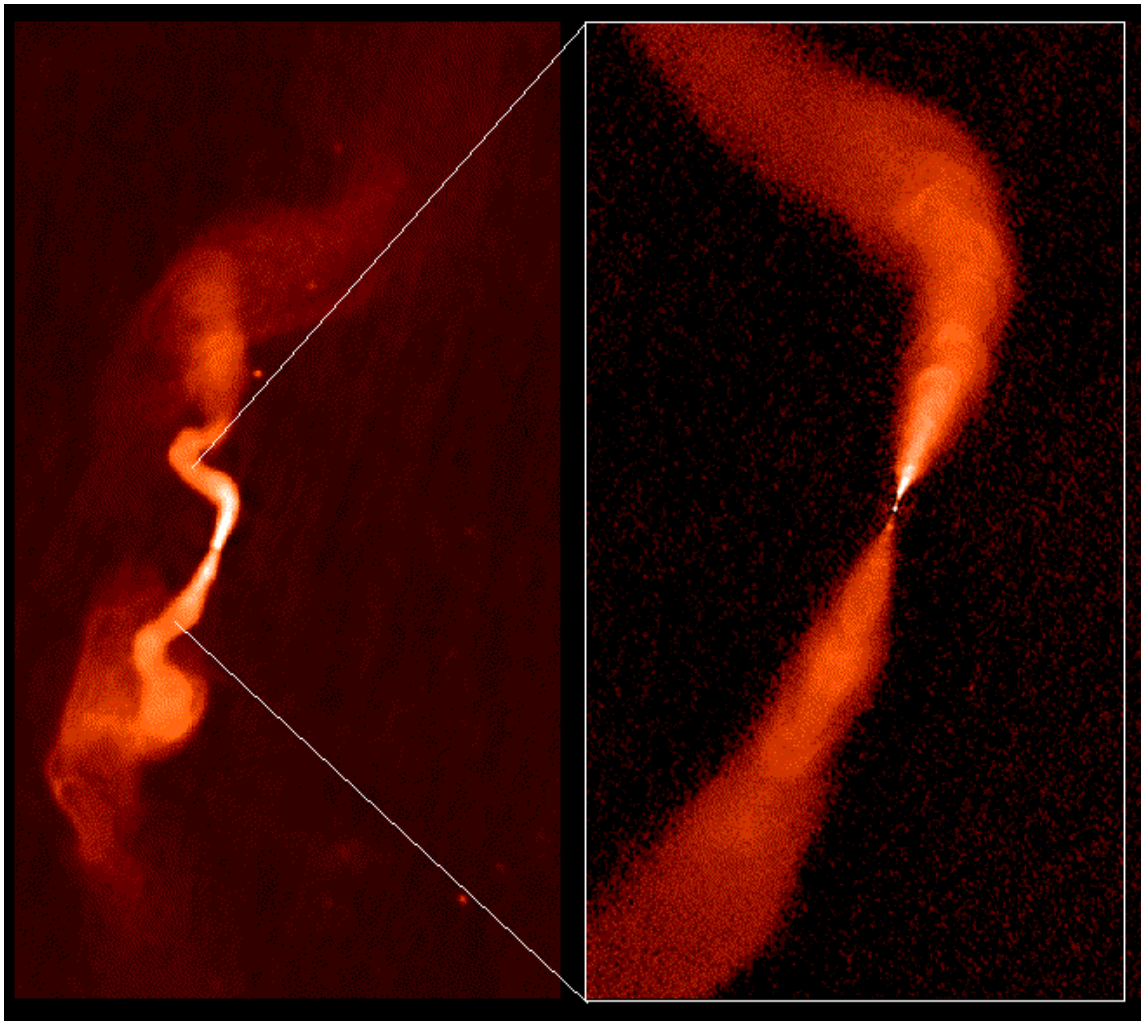


Red: VLA radio images
Blue: Optical images

3C31 jets develop symmetry – why?

300 kpc field, 1.9 kpc FWHM

40 kpc field, 85 pc FWHM



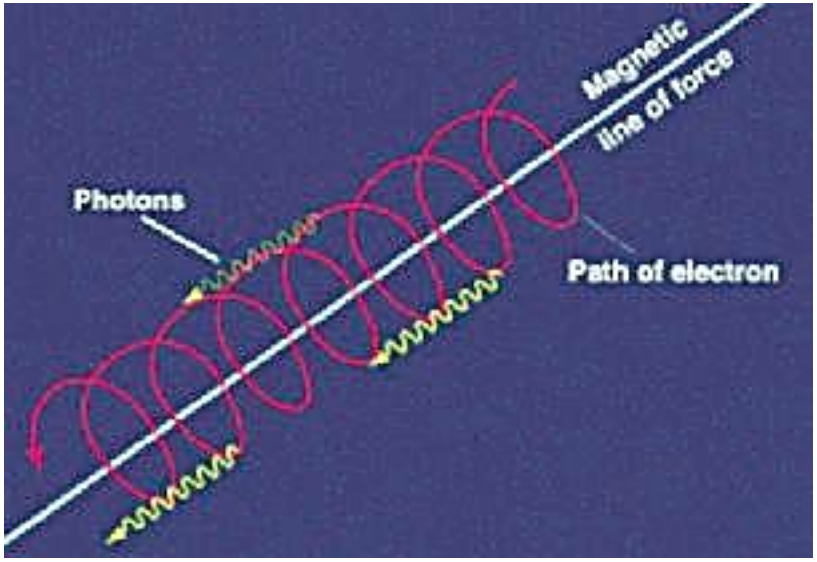
1.4 GHz

8.4 GHz

Synchrotron radiation

Must accelerate electron to make it radiate

Relativistic electrons accelerated by Lorentz force in magnetic field → efficient mechanism



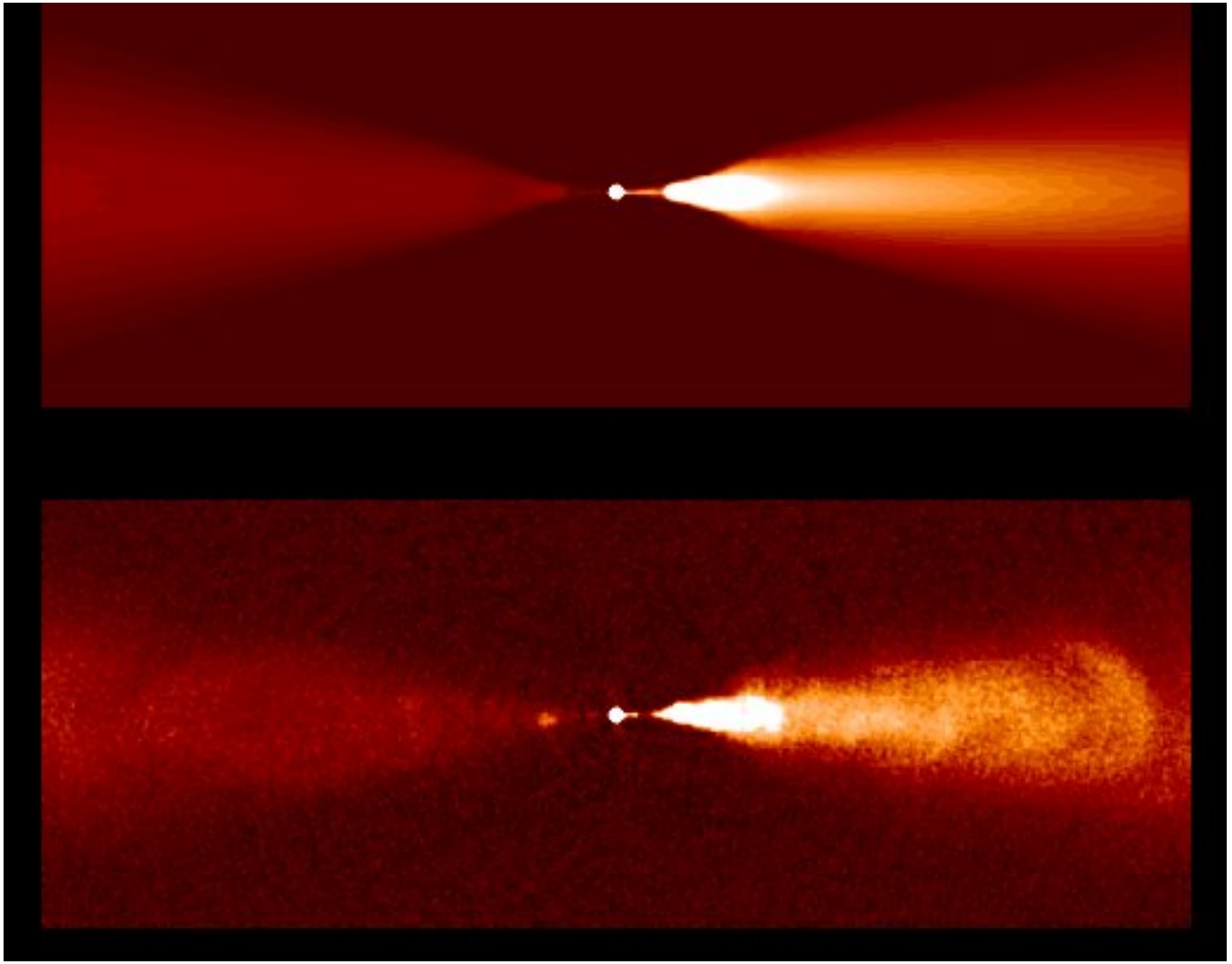
Radio galaxies contain "cosmic ray" electrons moving at close to speed of light in large-scale magnetic fields.

Radio jets are outflows of fast electrons and magnetic fields expelled from active galactic nuclei, with flow velocities also close to that of light … "relativistic jets"

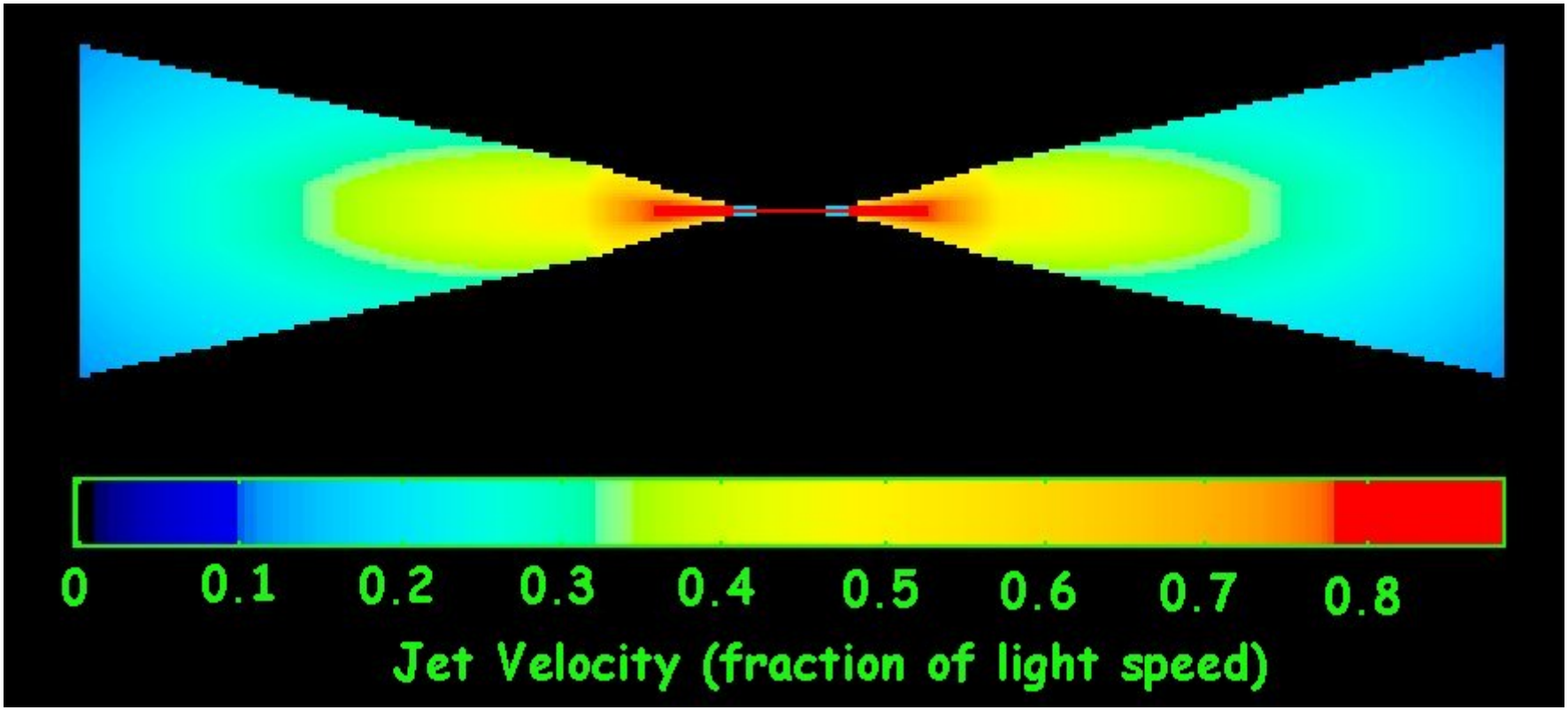
Relativistic jet modeling

Predicted radio emission from slowing relativistic twin-jet

Observed VLA data, fitted by model

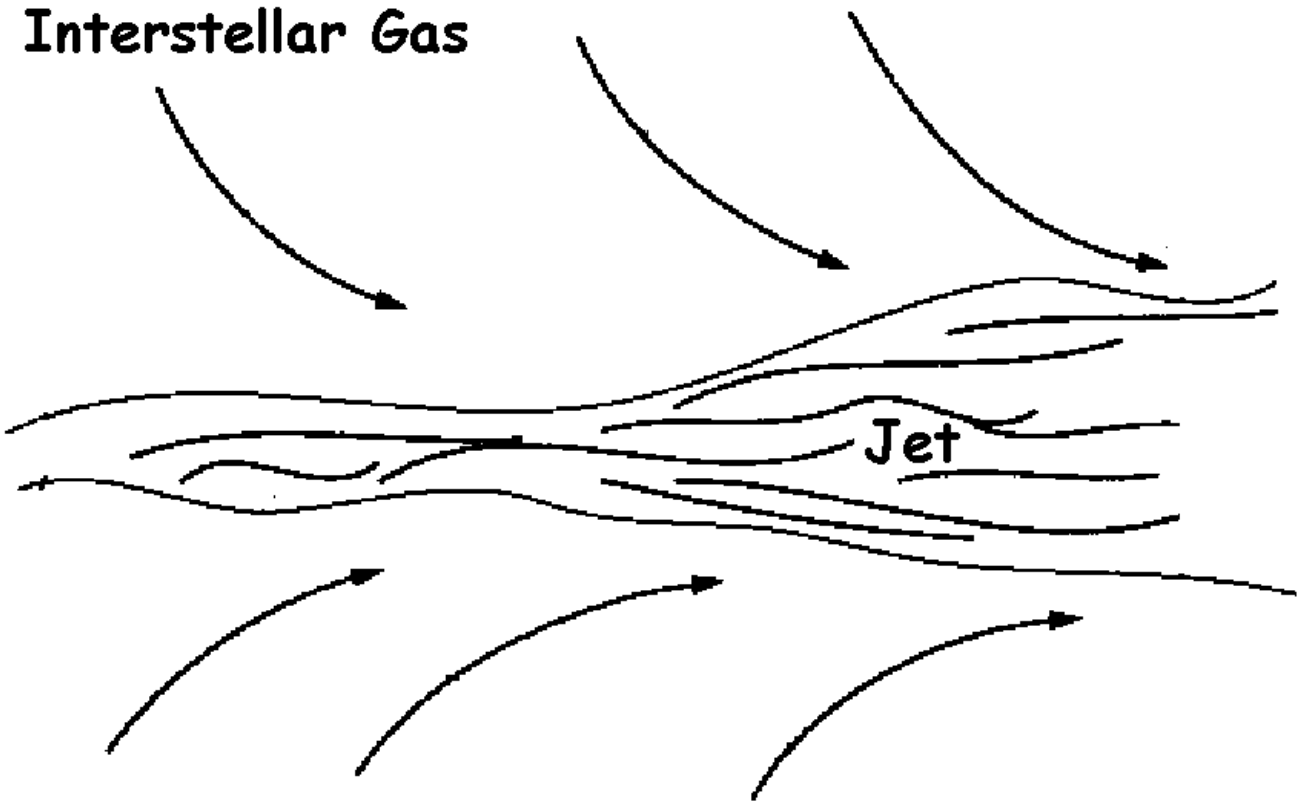


Inferred jet velocities in 3C31



Modeling VLA data shows how the jets slow down as they escape from the parent galaxy NGC383, but does not say why … gives kinematics, not dynamics

Entrainment into Jet



Turbulent boundary layer→ eddies → mass ingestion → "loading" of jet

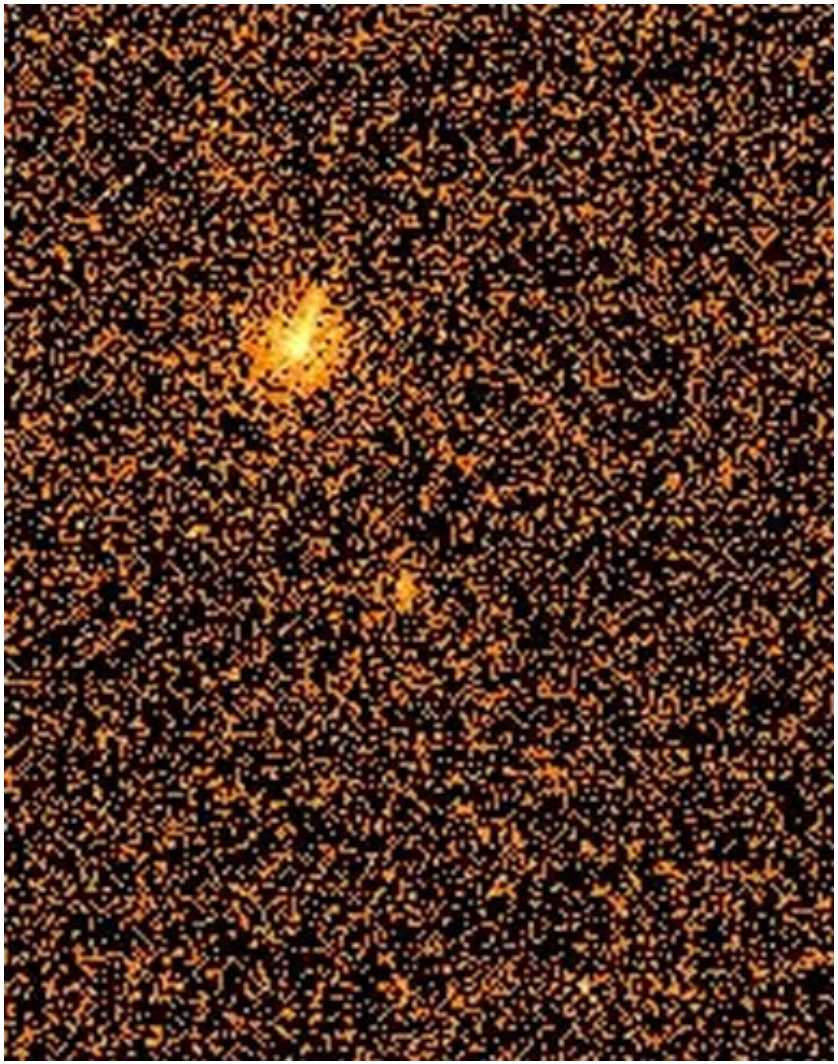
Interstellar gas ends up inside decelerating jet, we study interaction

Chandra X-ray image, Nov 2000

Detects gas in NGC383 through which jet travels, also enhanced emission along jet path (origin?)

Will add pressure gradient constraint to slowdown models → mass flux in jet

Kinematics → Dynamics



0.5 to 7 keV Chandra image