

Lecture 9: Quasars & “Active” Galaxies

Astronomy 5: The Formation and Evolution of the Universe

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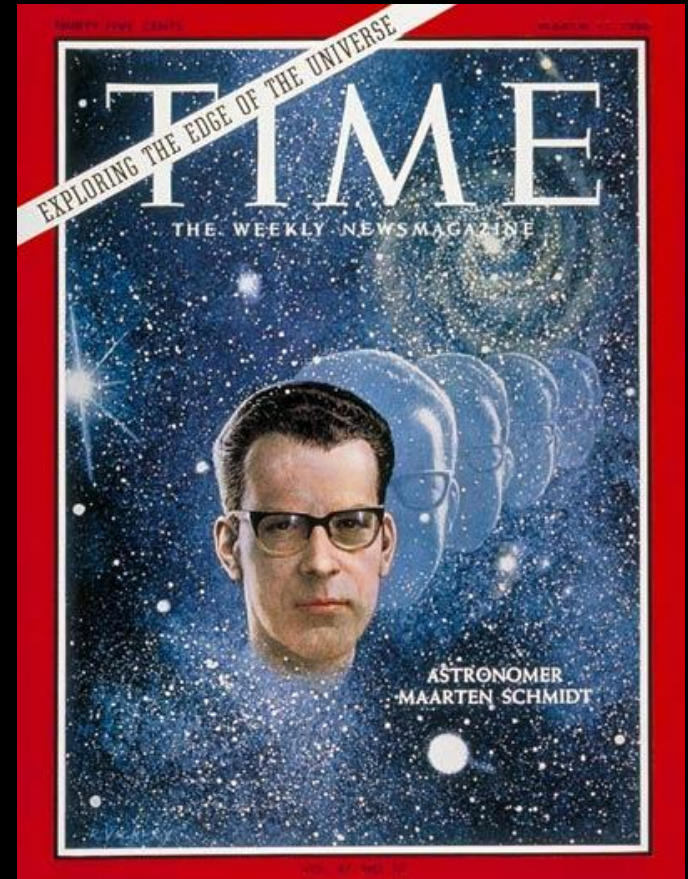
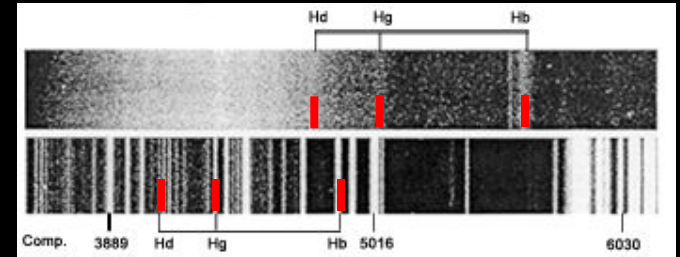
UC Santa Cruz

Maarten Schmidt identified the first quasar 3C273 in 1963

Diffraction spikes produced in telescope; only for point source. Shows quasar is star-like.



$z = 0.158 \Rightarrow 2 \text{ billion lyr}$

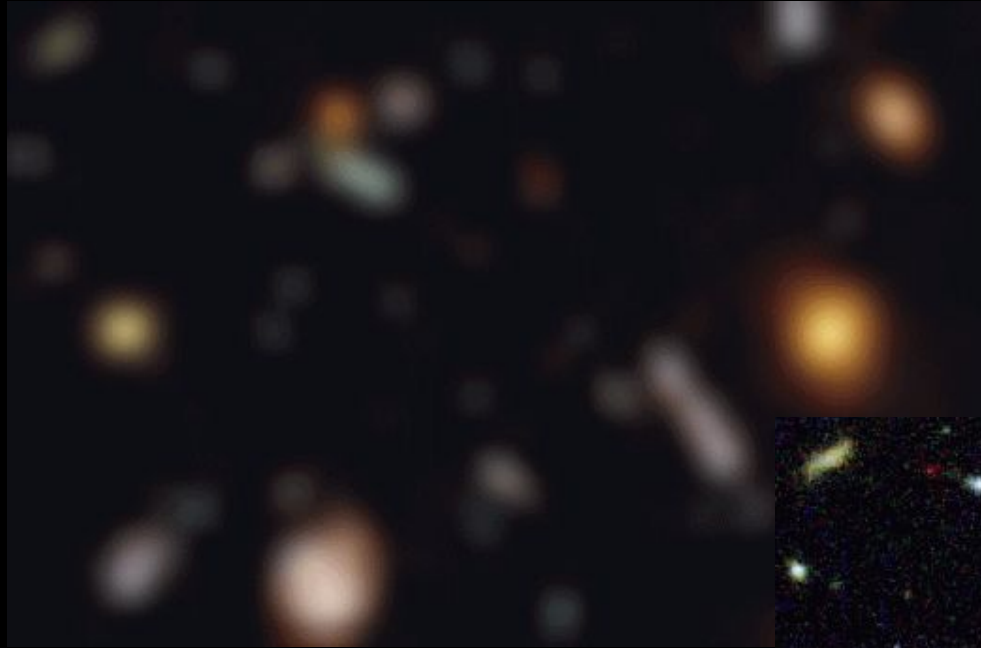


3C48 was the second quasar, found soon after

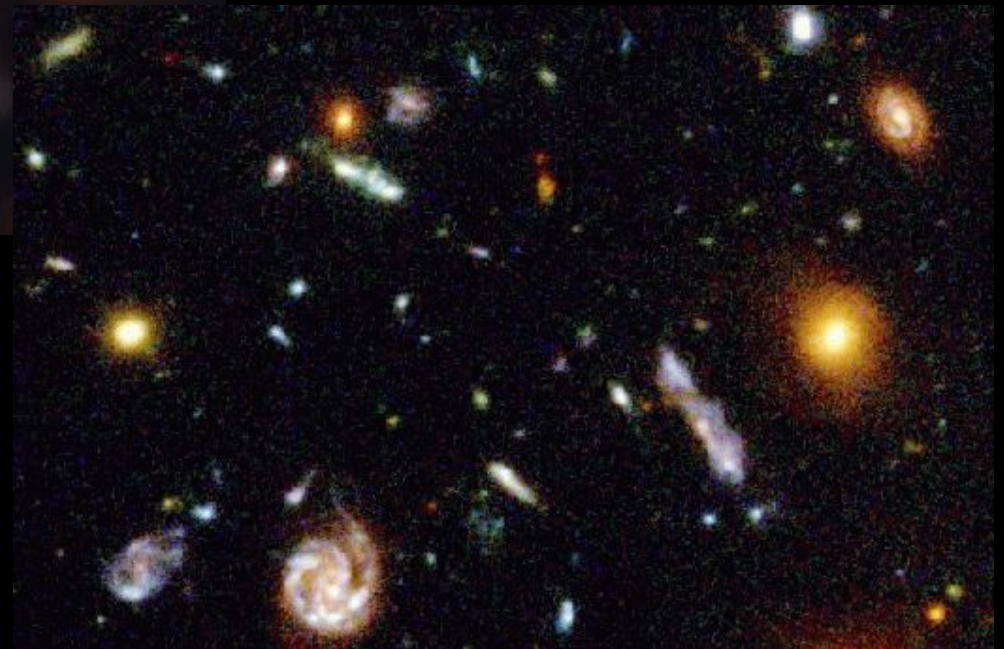
$z = 0.367 \Rightarrow 4$ billion yr



Comparing the resolution of HST with a ground-based photo

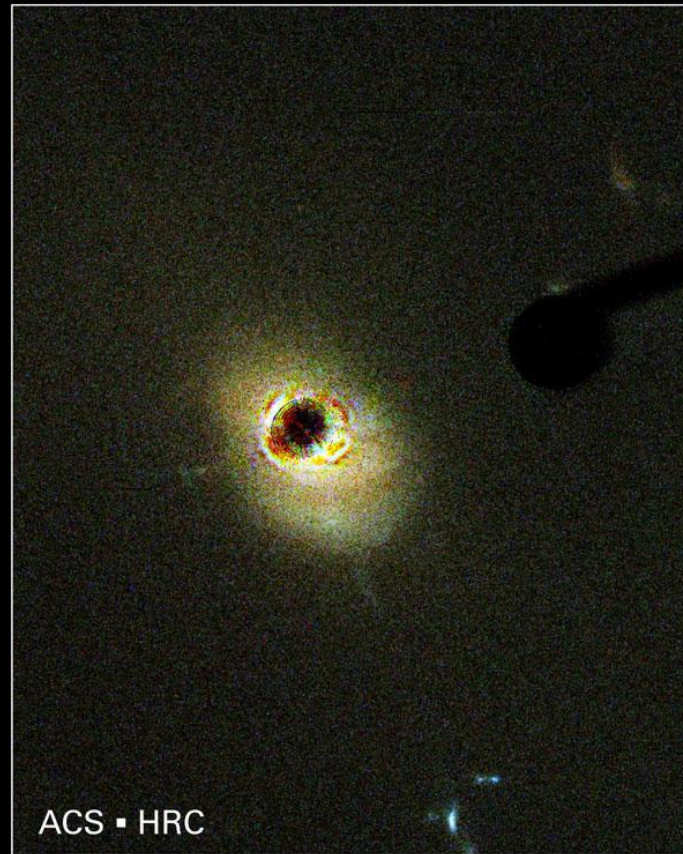
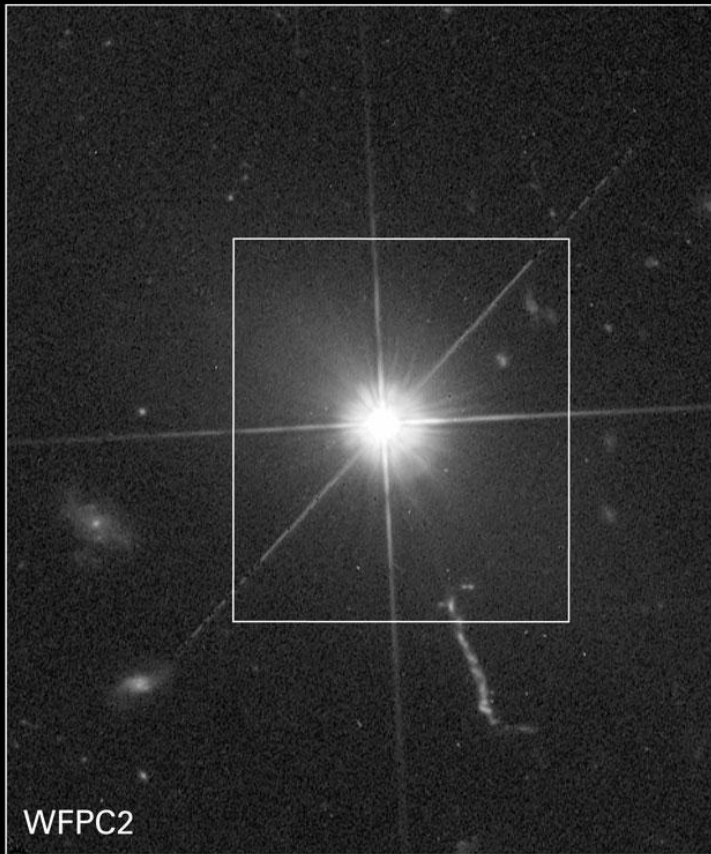


Ground



Hubble Space Telescope

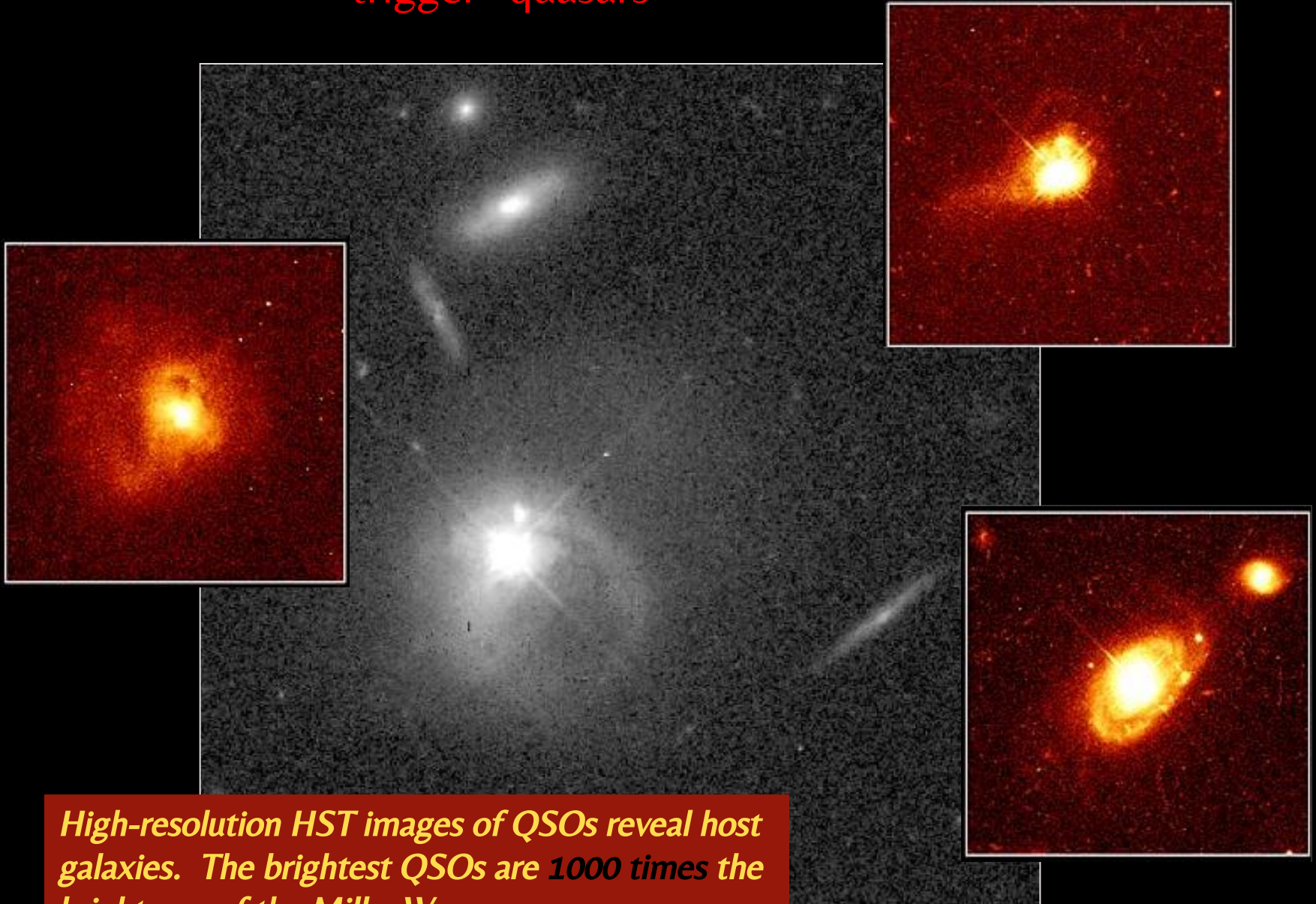
With the high resolution of HST, we could subtract off the bright star-like quasar to reveal the underlying galaxy clearly for the first time



Quasar 3C 273
Hubble Space Telescope • ACS HRC Coronagraph

NASA, A. Martel (JHU), the ACS Science Team, J. Bahcall (IAS) and ESA • STScI-PRC03-03

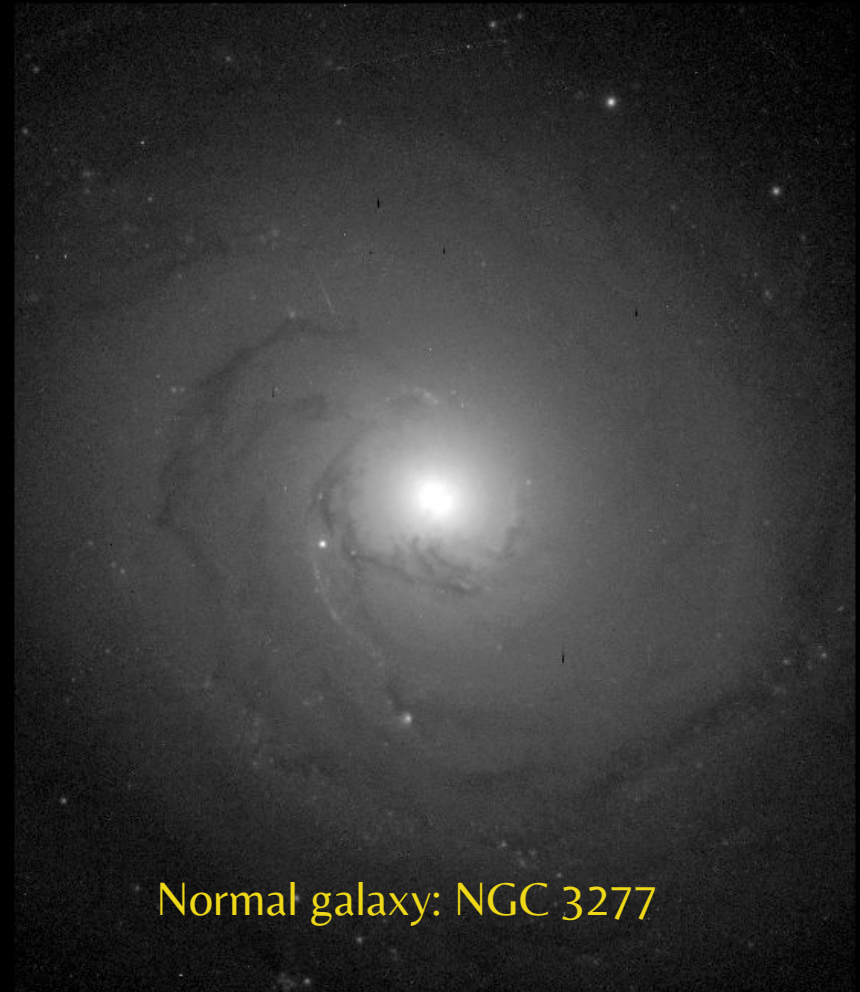
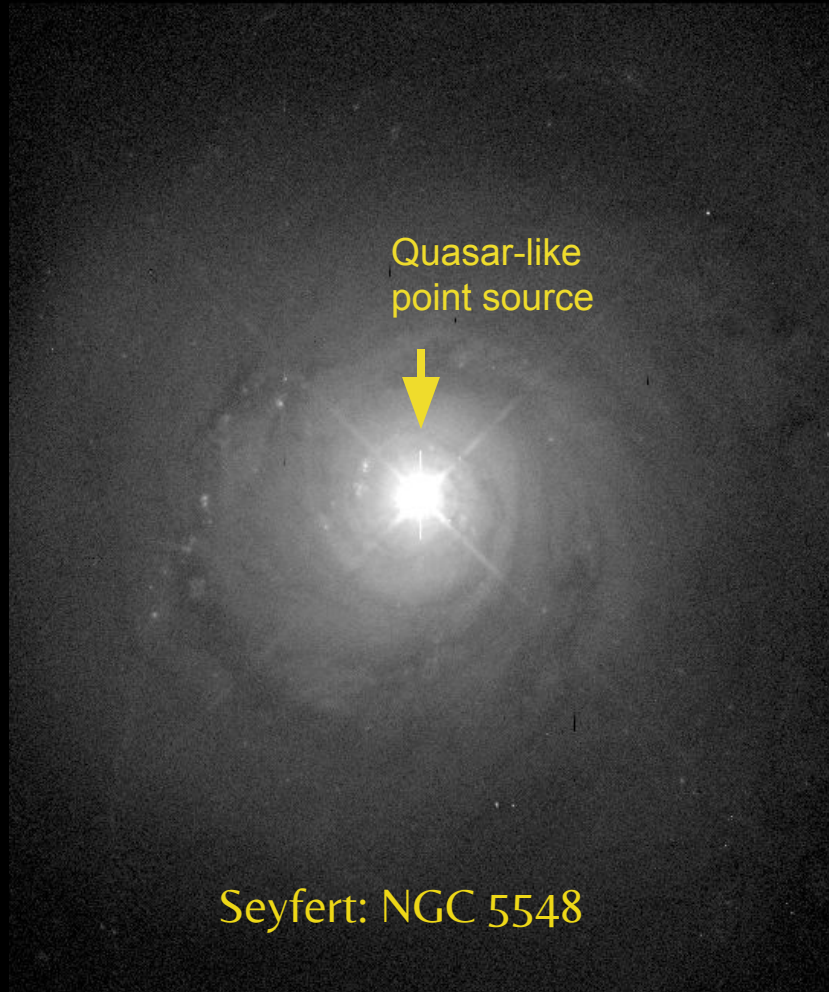
Many quasars are found in colliding galaxies; mergers
“trigger” quasars



High-resolution HST images of QSOs reveal host galaxies. The brightest QSOs are 1000 times the brightness of the Milky Way.

Black holes can shine by having an “accretion disk”

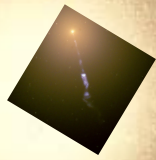
Seyfert galaxies are AGNs of intermediate brightness in galaxies that are **not** disturbed



The relationship of Seyferts to quasars is unclear, but they are believed to also shine by active black holes.

M87: A nearby giant elliptical galaxy with central AGN and radio “jet”

3 billion M_{\odot} central black hole



M87 nearby giant elliptical

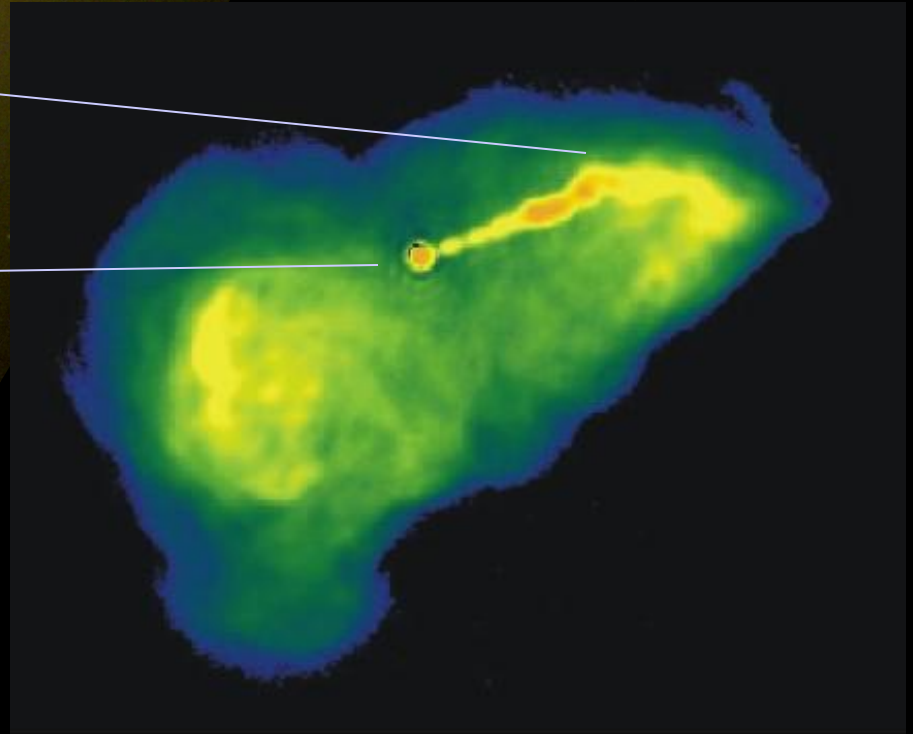
M87: A nearby giant elliptical galaxy with central AGN and radio “jet”

3 billion M_{\odot} black hole



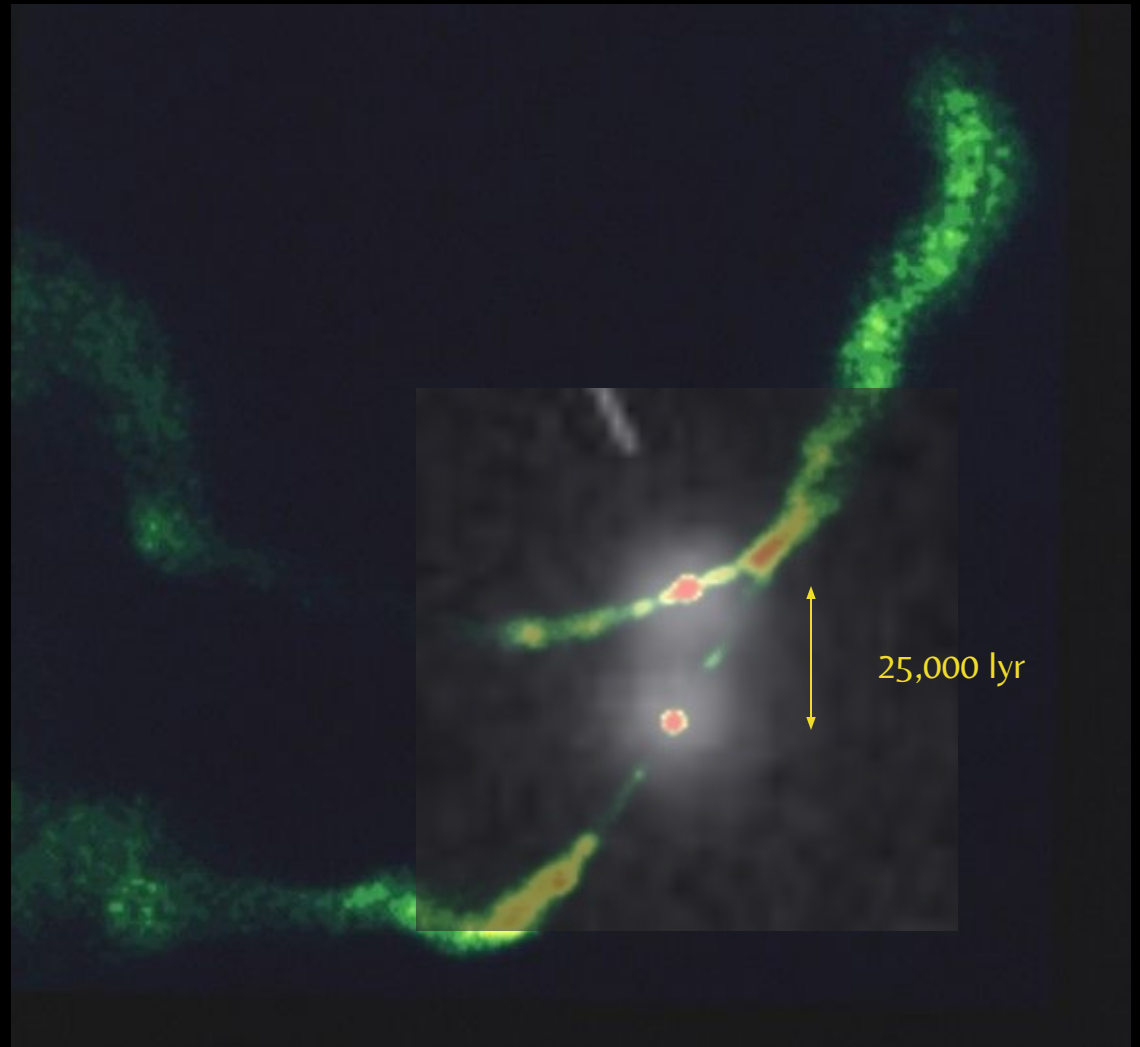
VLA radio image

M87 nearby giant



A pair of galaxies in the process of merging, each with its own black hole and radio jets

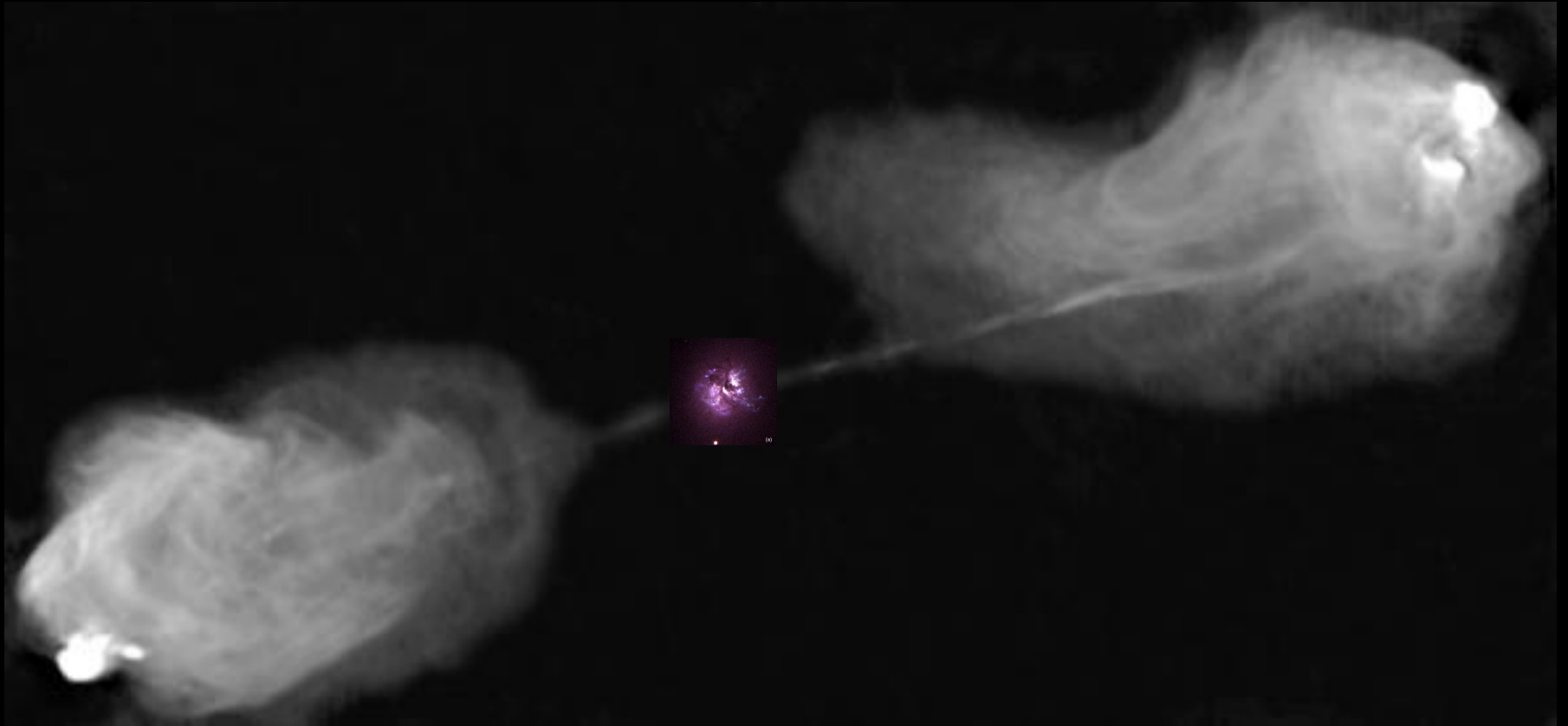
An optical image showing the galaxies as two fuzzy blobs superimposed on the VLA radio image showing the radio jets.



$Z = 0.023 \Rightarrow 320$ million lyr

Cygnus A: one of the largest radio galaxies in the Universe

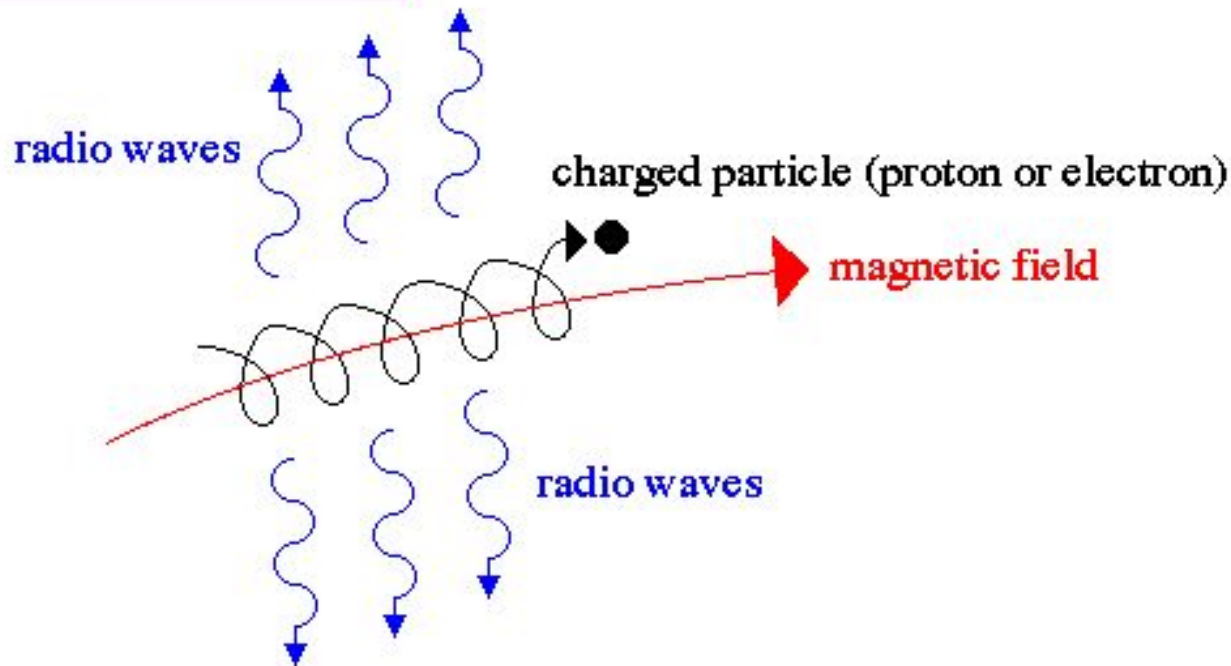
← 500,000 light years →



$Z = 0.056$

Radio galaxies shine by emitting *synchrotron radiation*

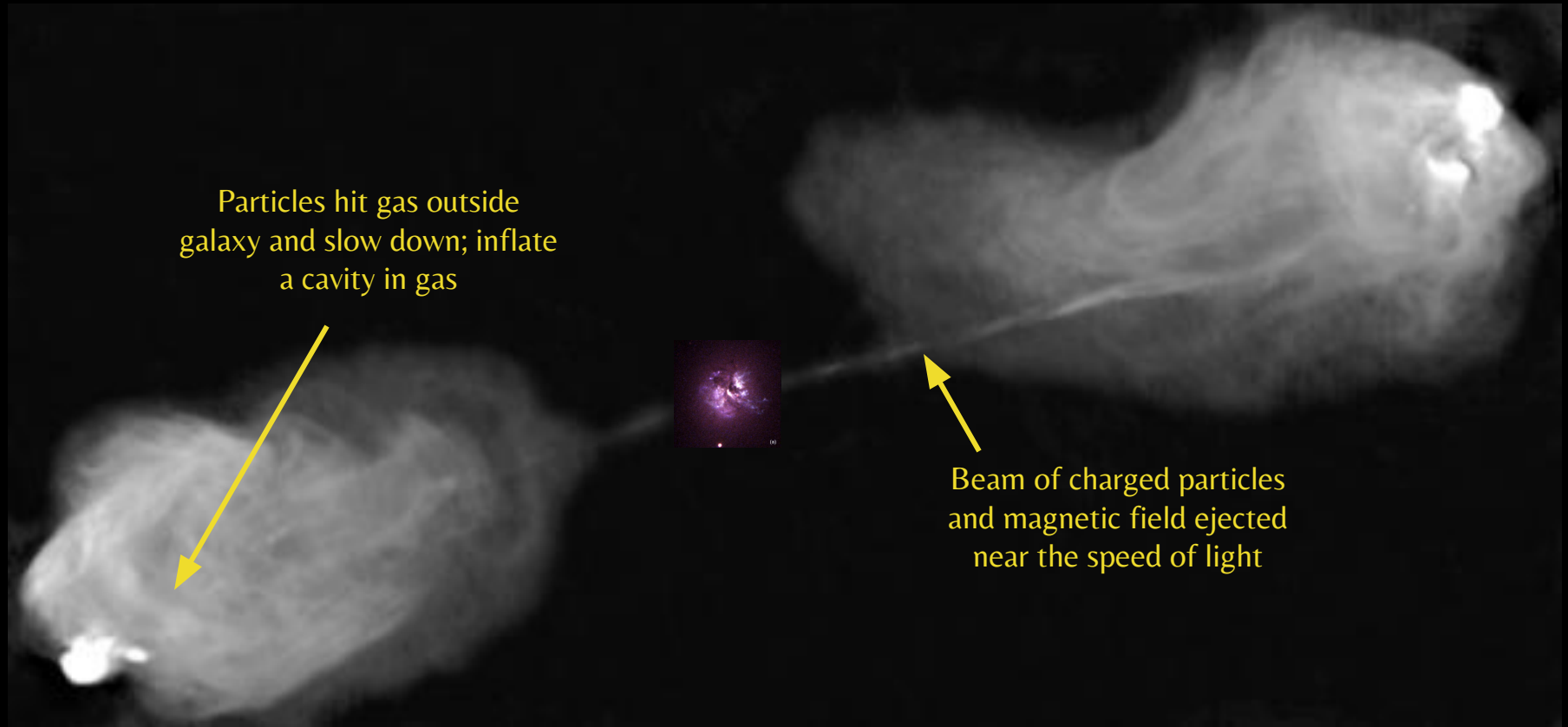
Synchrotron Radiation



synchrotron radiation occurs when a charged particle encounters a strong magnetic field – the particle is accelerated along a spiral path following the magnetic field and emitting radio waves in the process – the result is a distinct radio signature that reveals the strength of the magnetic field

Cygnus A: one of the largest radio galaxies in the Universe

500,000 light years



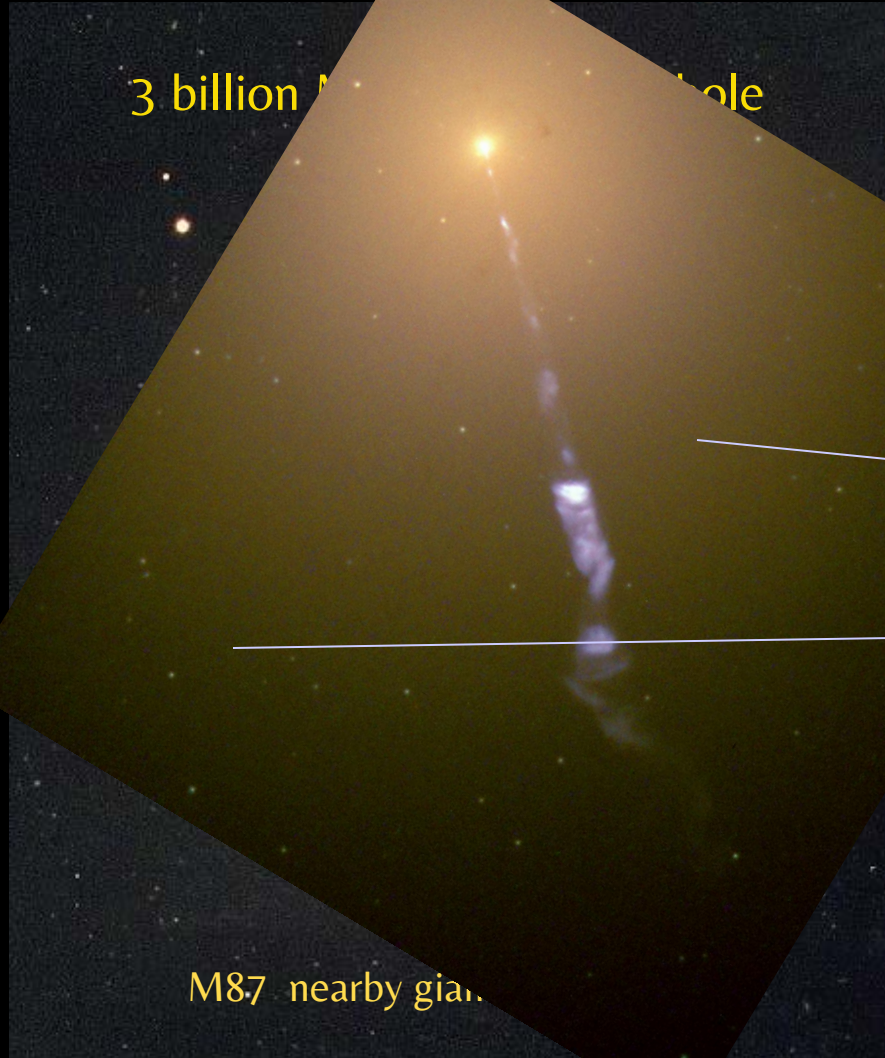
Particles hit gas outside galaxy and slow down; inflate a cavity in gas

Beam of charged particles and magnetic field ejected near the speed of light

$Z = 0.056$

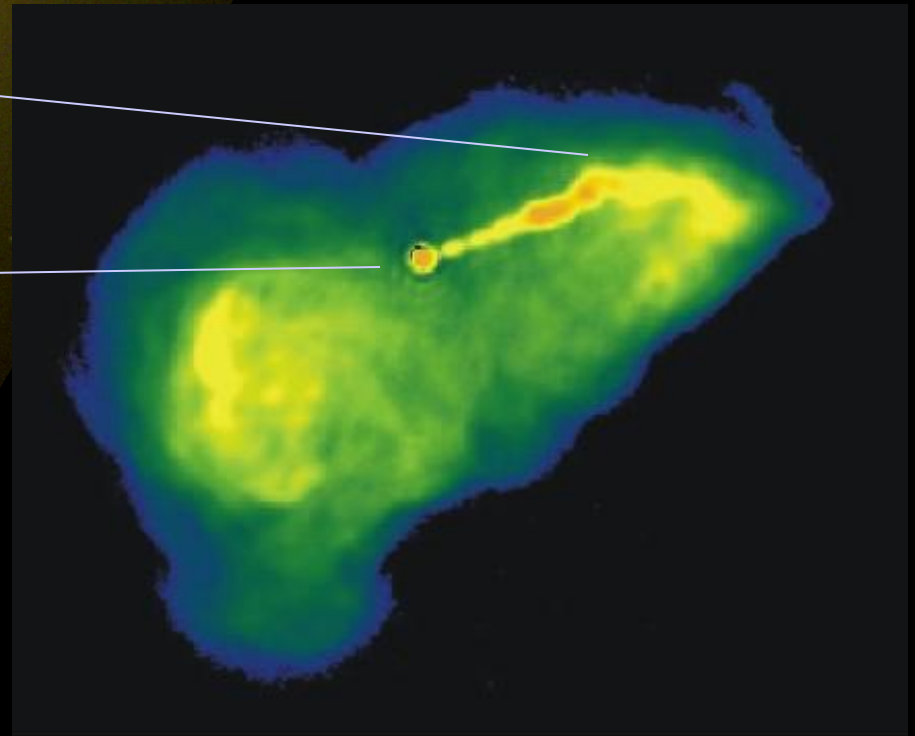
M87: A nearby giant elliptical galaxy with central AGN and radio “jet”

3 billion M_☉ supermassive black hole

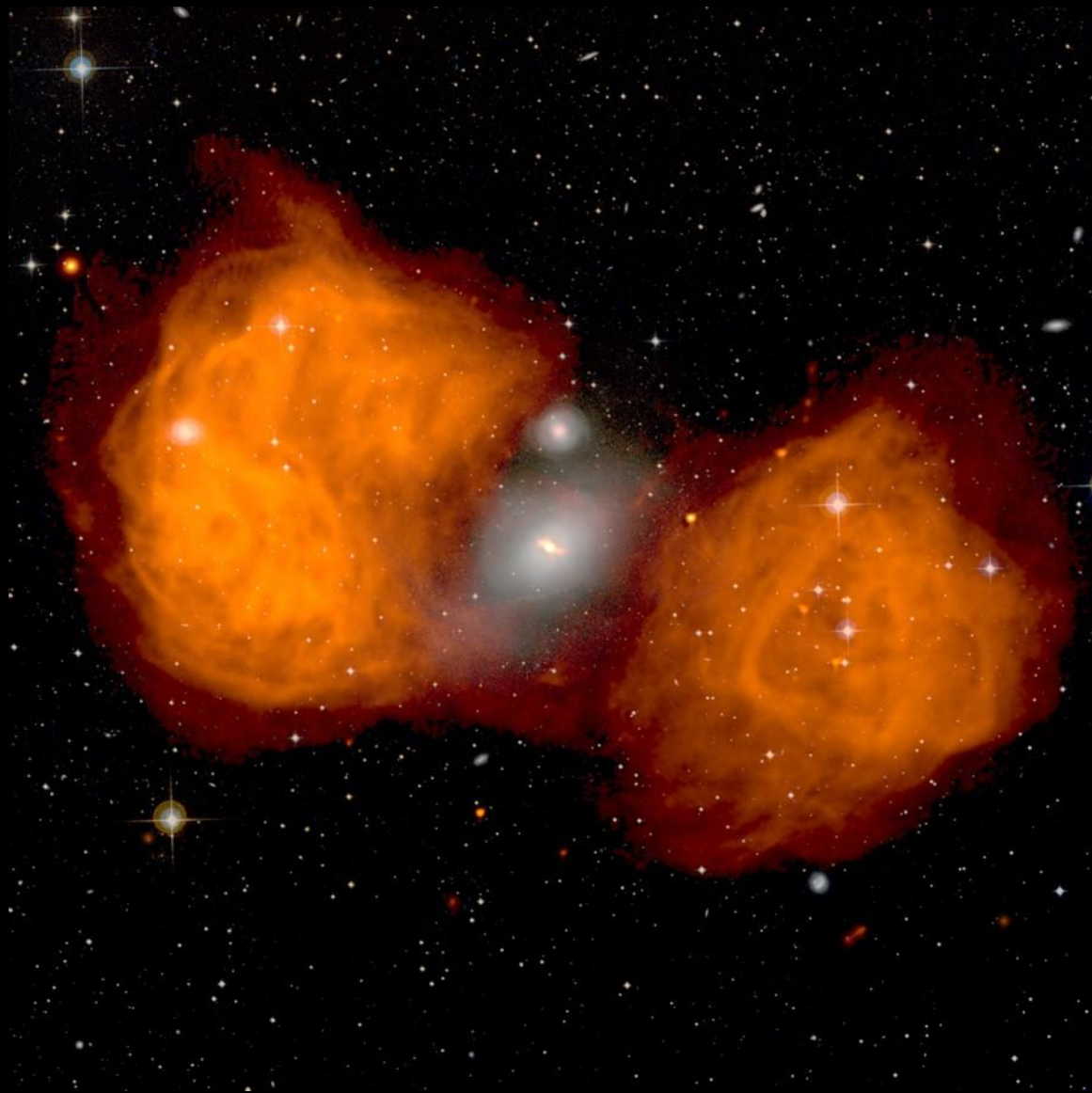


M87 nearby giant

VLA radio image

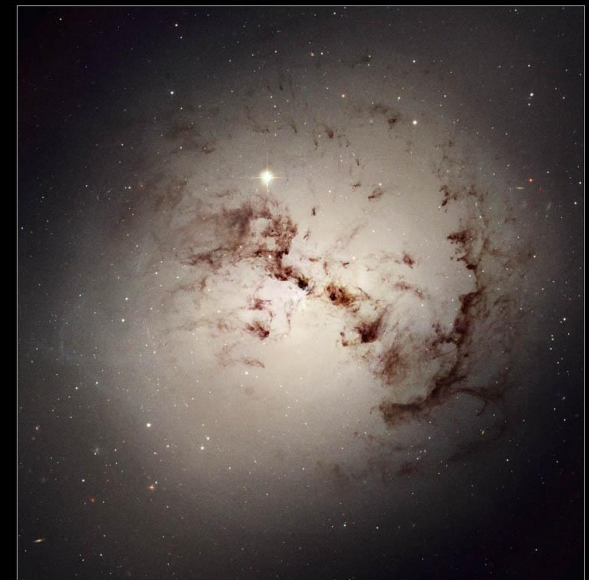


Weaker radio galaxies have “fluffier” radio lobes



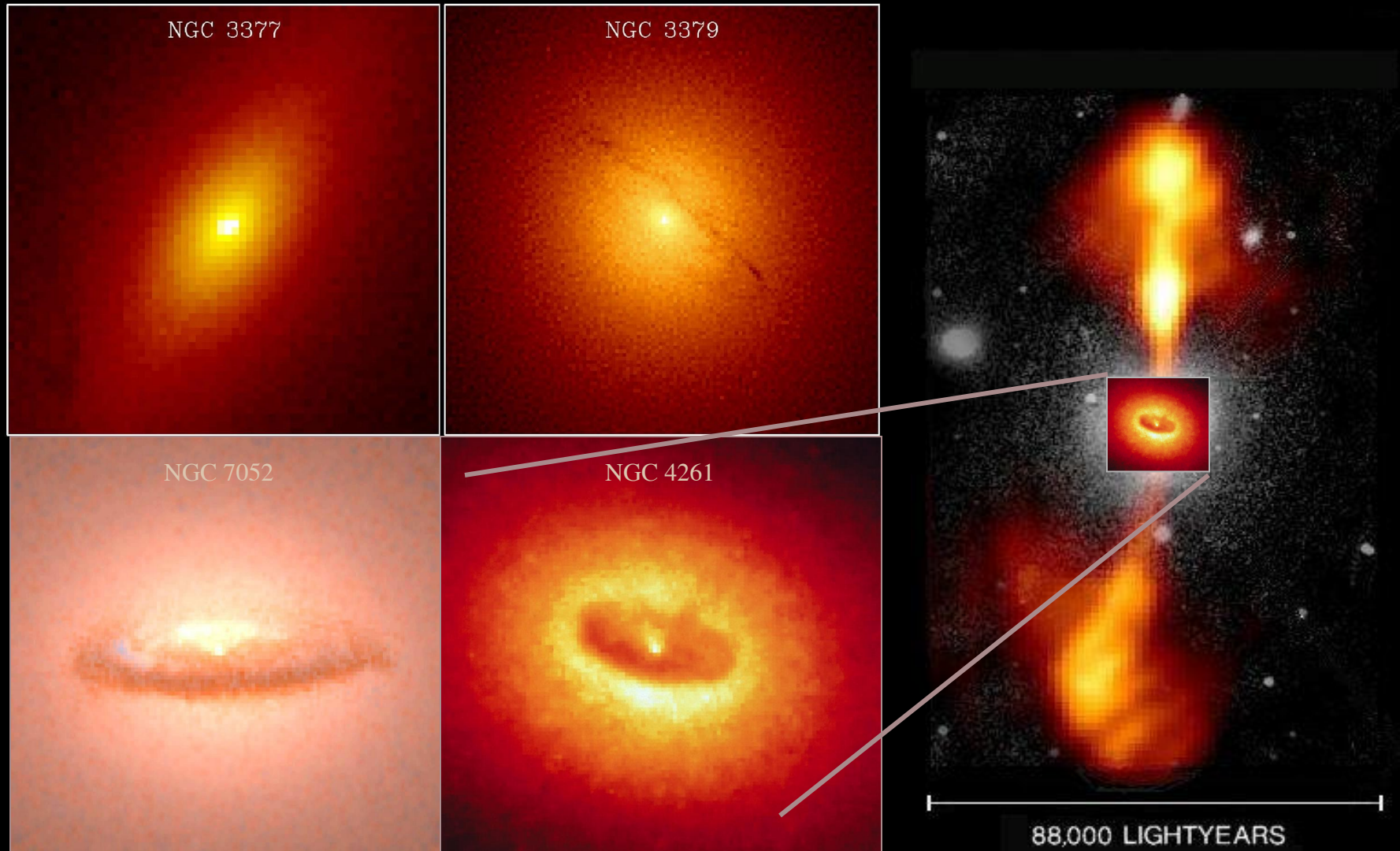
The peculiar nearby elliptical NGC 1316 with radio lobes

Elliptical Galaxy NGC 1316



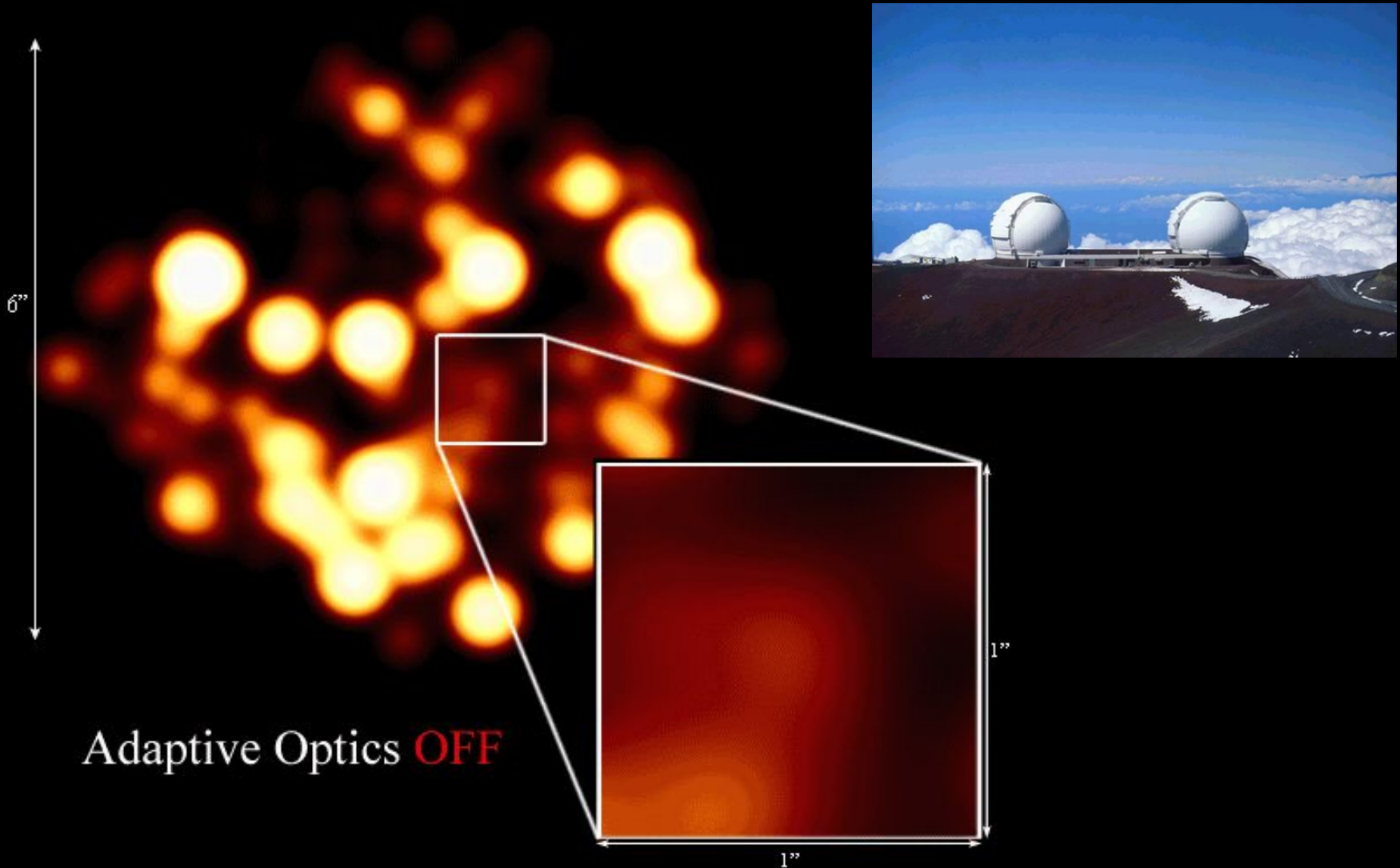
Hubble
Heritage

Spheroids host massive central black holes, which power quasars and other kinds of active galactic nuclei (AGNs)



Our Milky Way observed with *adaptive optics* at the 10-meter Keck telescope

The Galactic Center at 2.2 microns



Stars in orbit about the Milky Way's BH give a mass of 3 million solar masses

