Lecture 9: Quasars & "Active" Galaxies

Astronomy 5: The Formation and Evolution of the Universe

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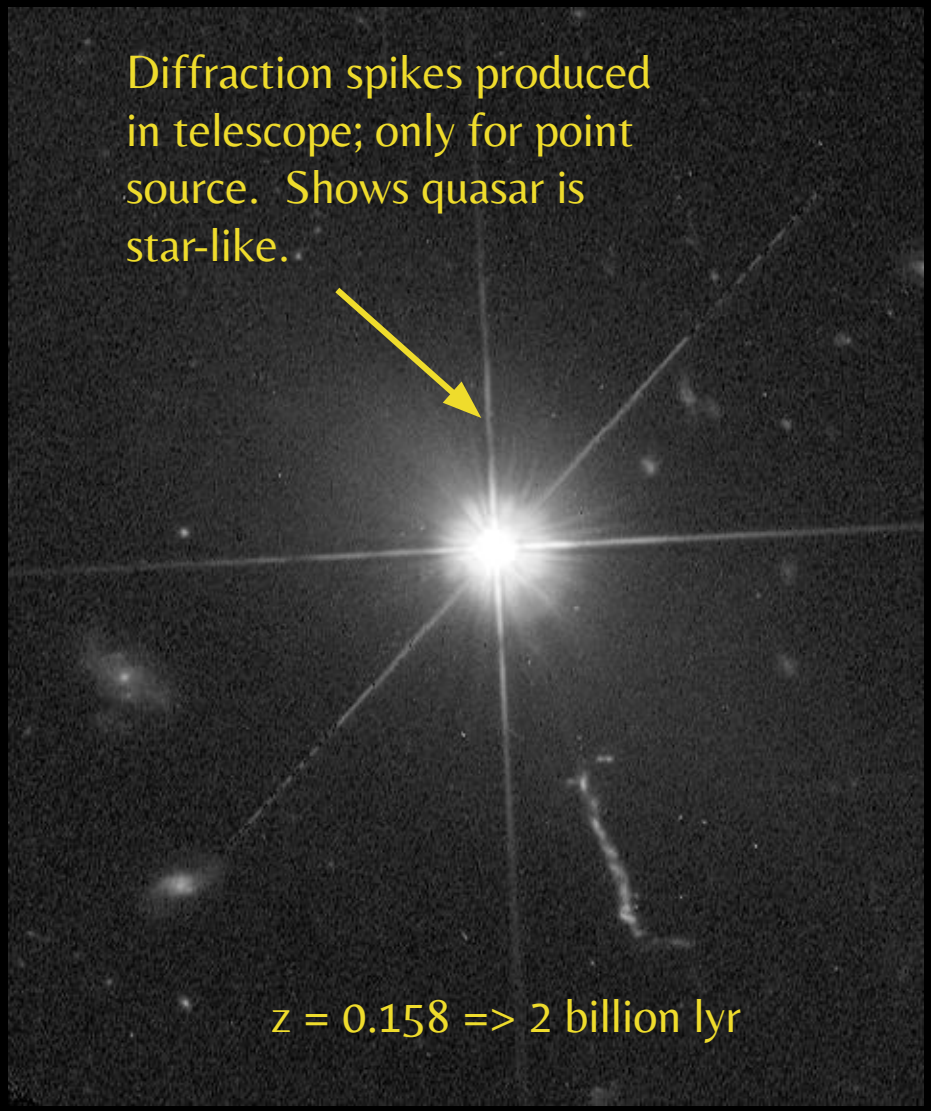
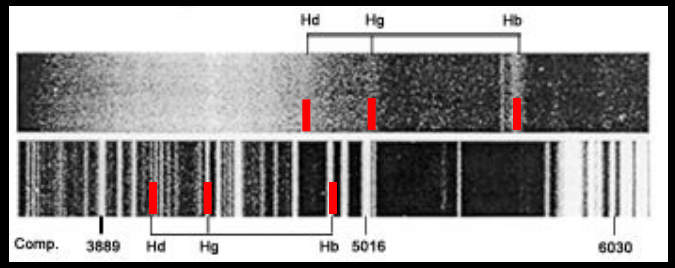
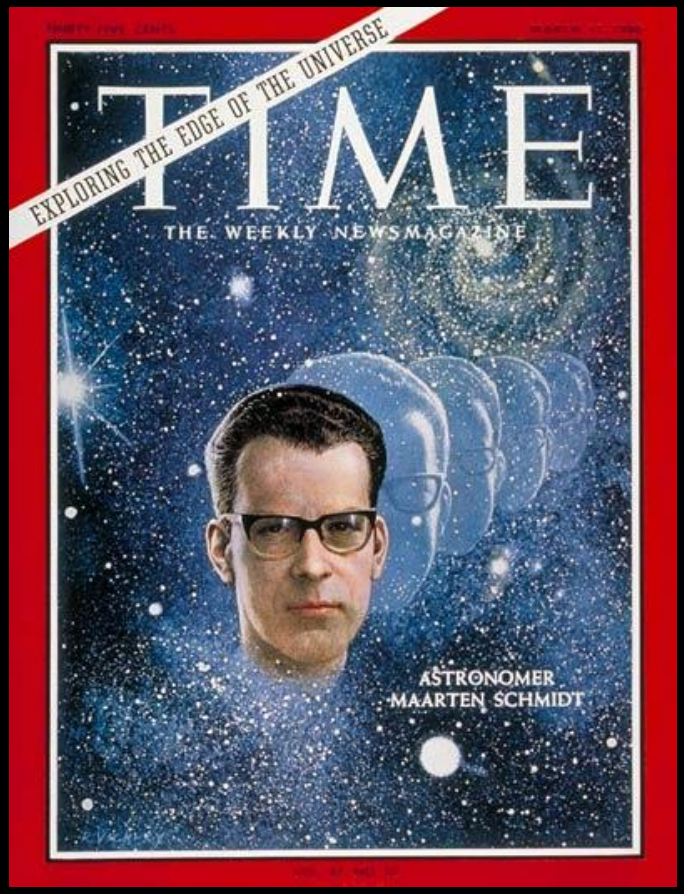
Maarten Schmidt identified the first quasar 3C273 in 1963



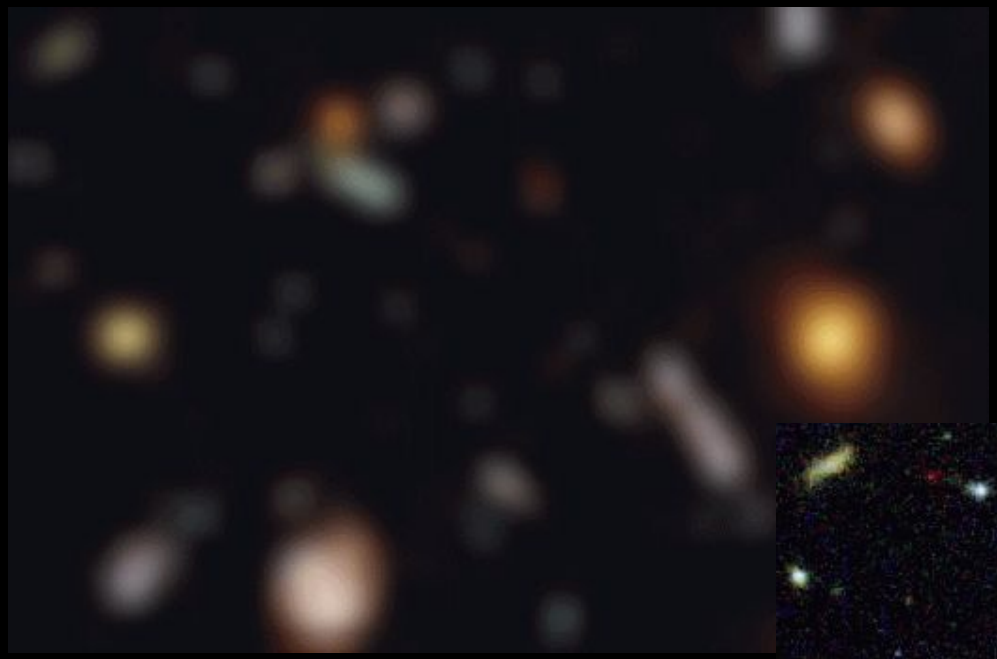




3C48 was the second quasar, found soon after

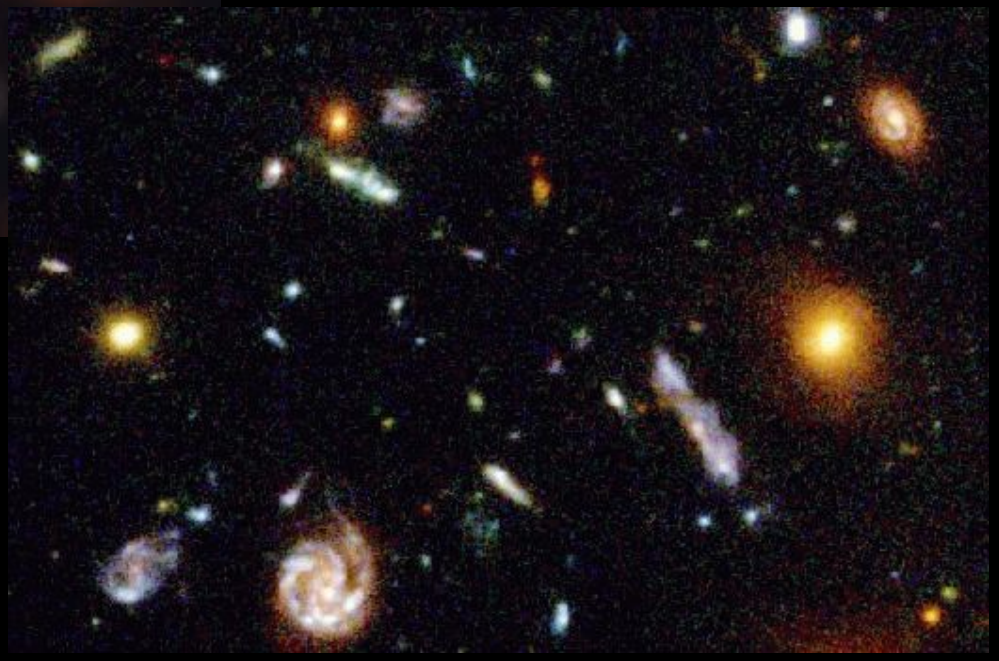
z = 0.367 => 4 billion lyr

Comparing the resolution of HST with a ground-based photo

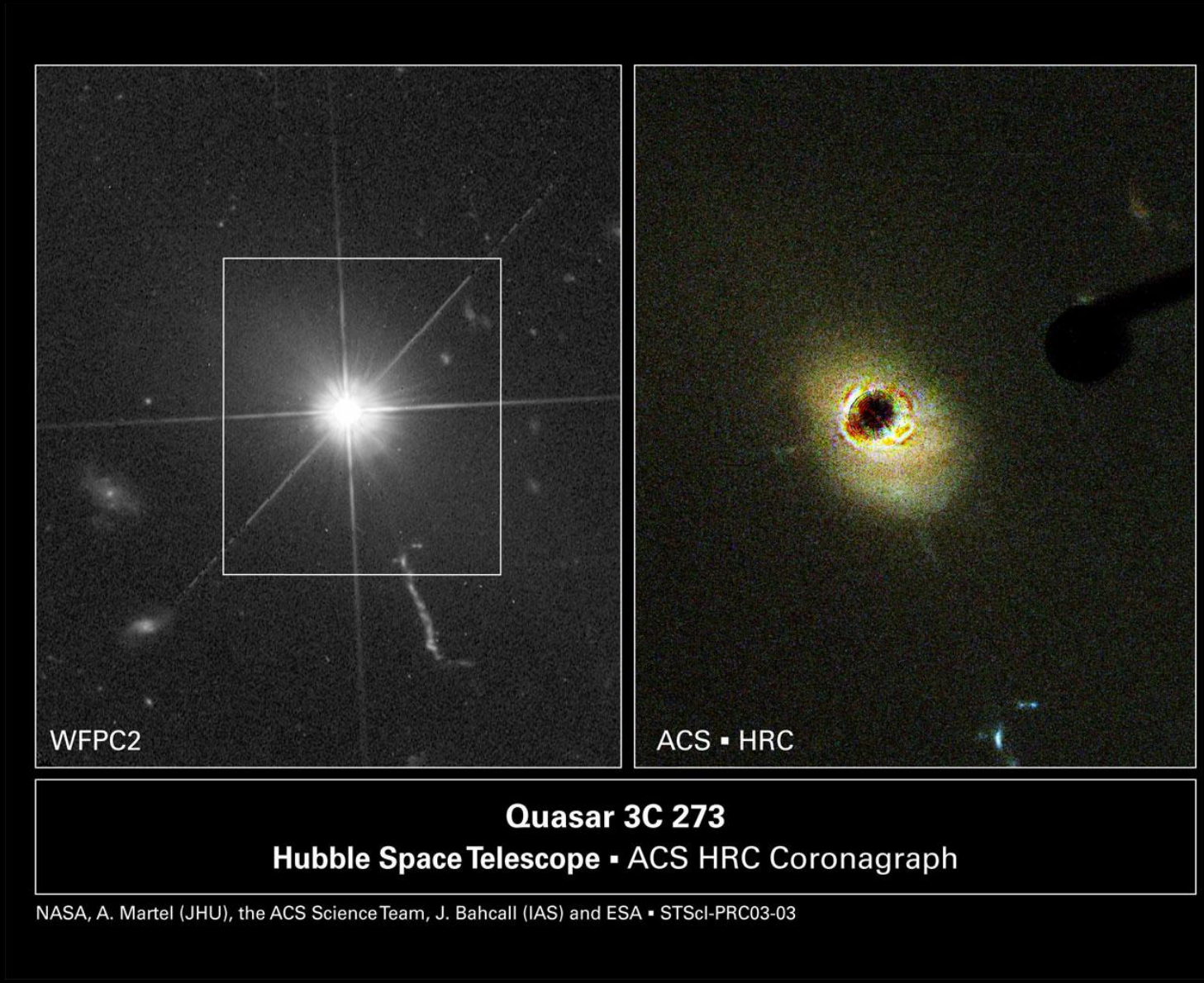


Ground

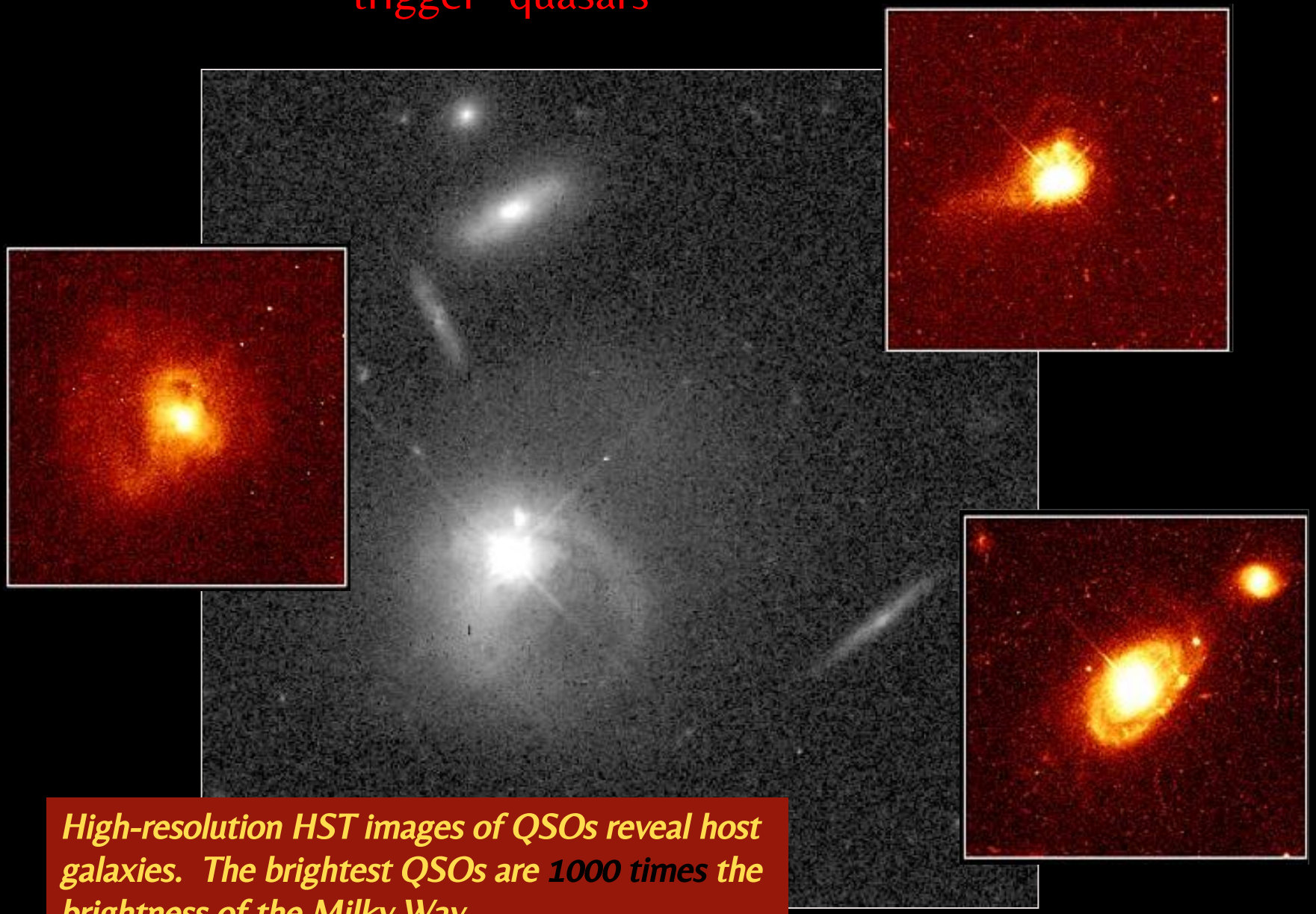
Hubble Space Telescope



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



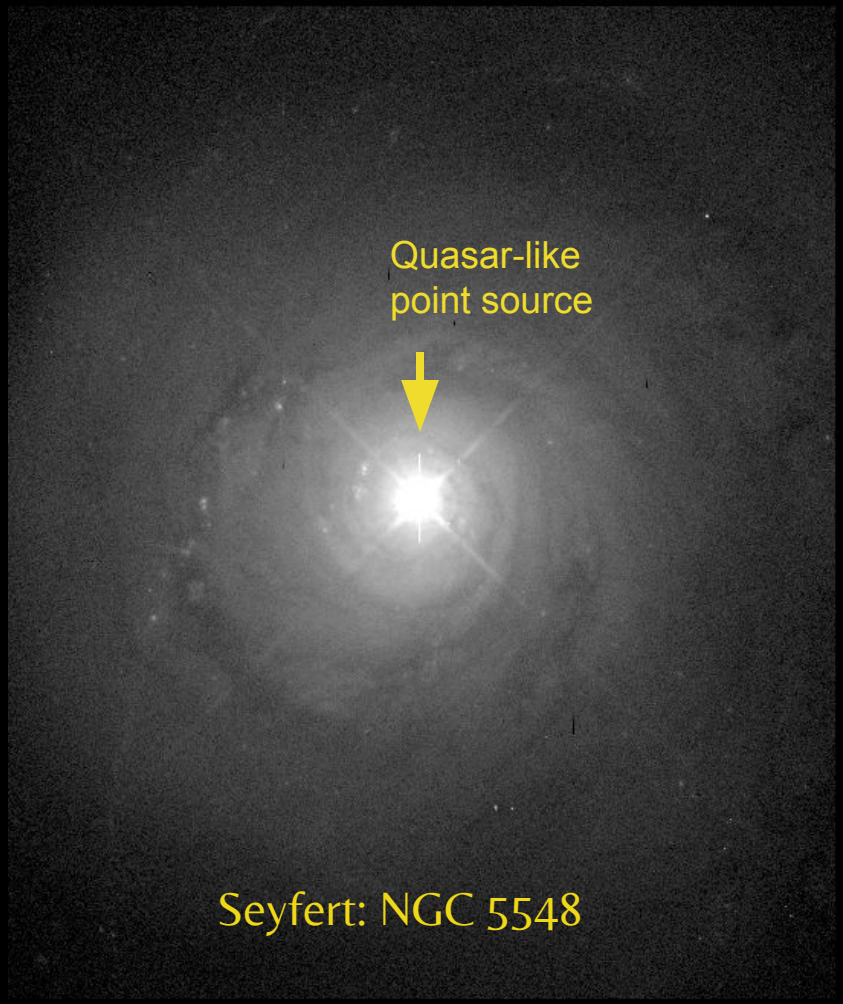
Many quasars are found in colliding galaxies; mergers "trigger" quasars



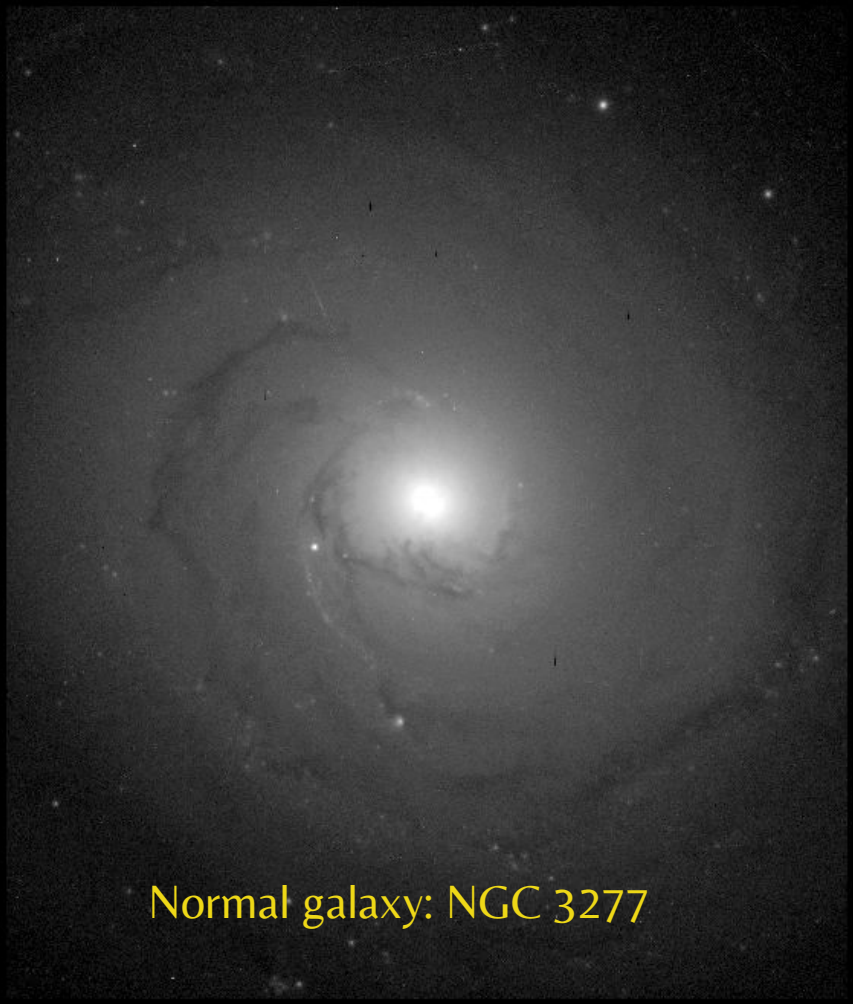
High-resolution HST images of QSOs reveal host galaxies. The brightest QSOs are 1000 times the brightness of the Milky Way.

Black holes can shine by having an “accretion disk”

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



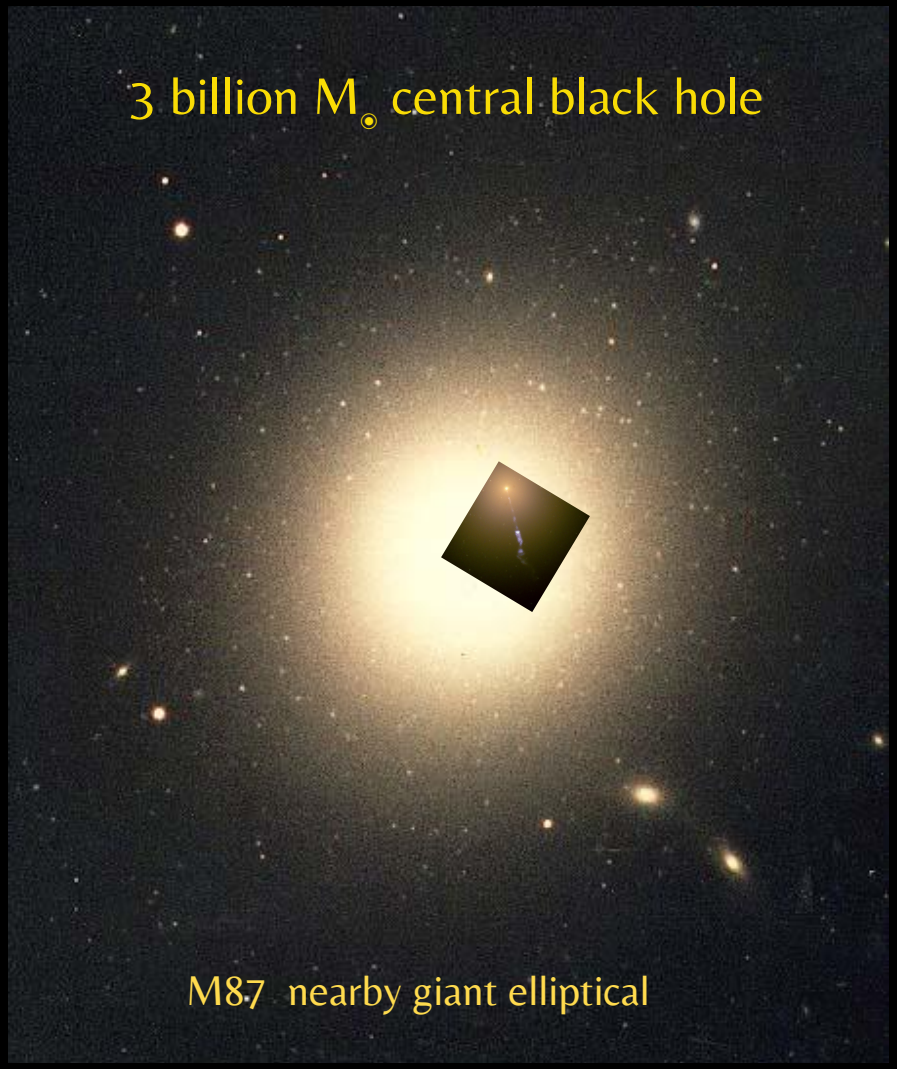
Seyfert: NGC 5548



Normal galaxy: NGC 3277

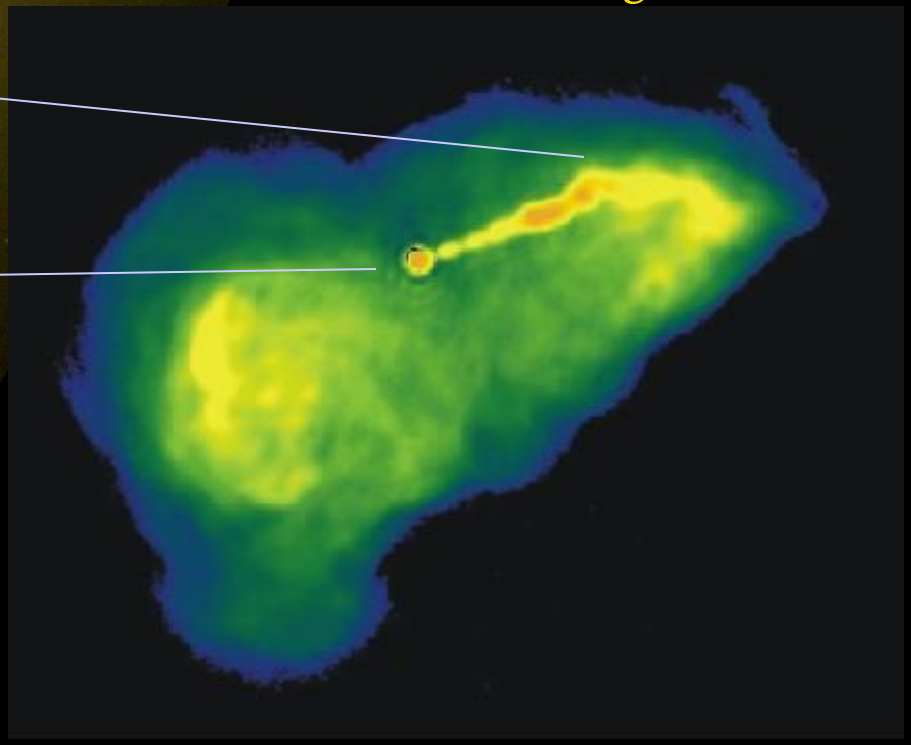
The relationship of Seyferts to quasars is unclear, but they are believed to also shine by active black holes.

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



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

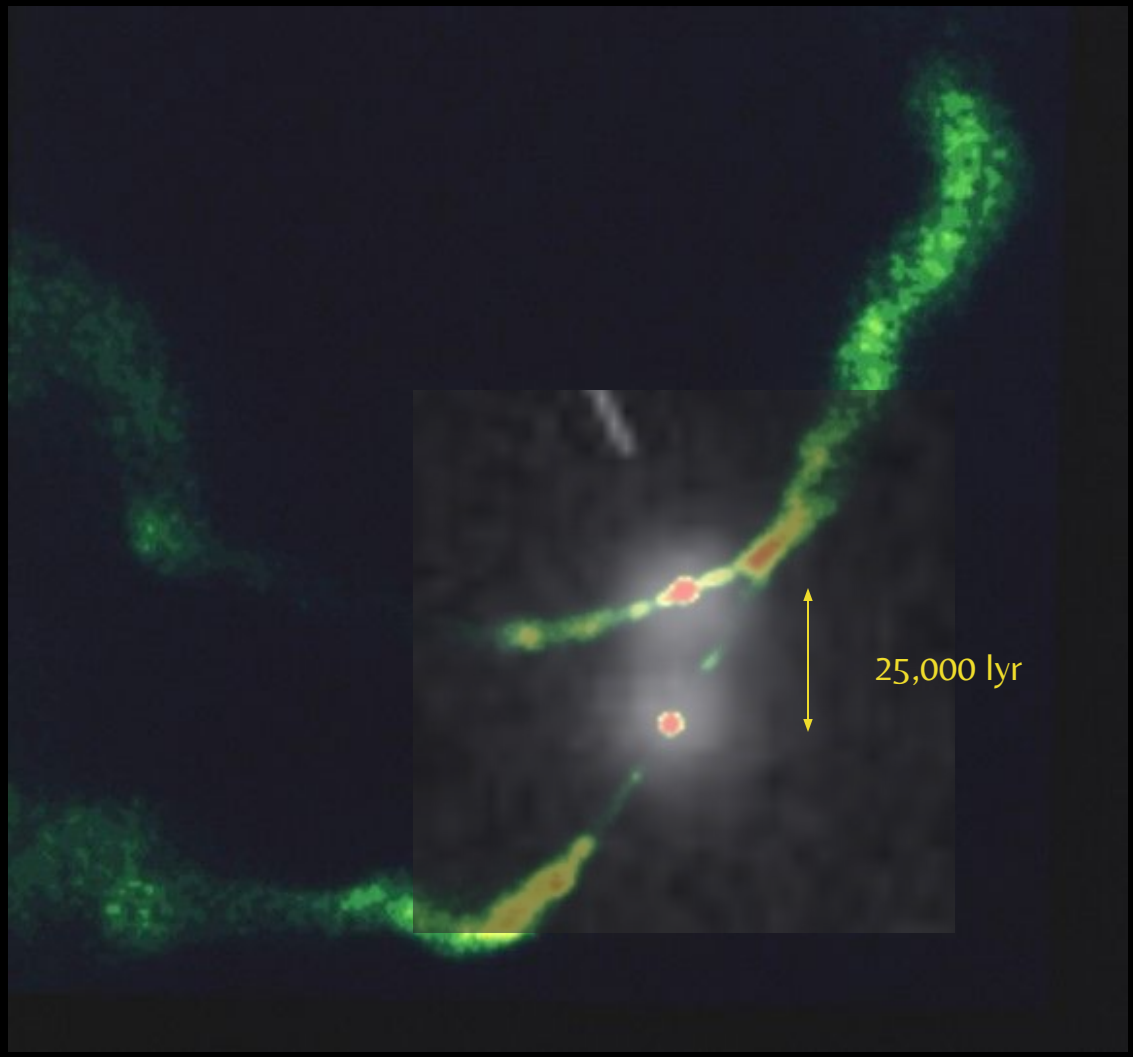
VLA radio image



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

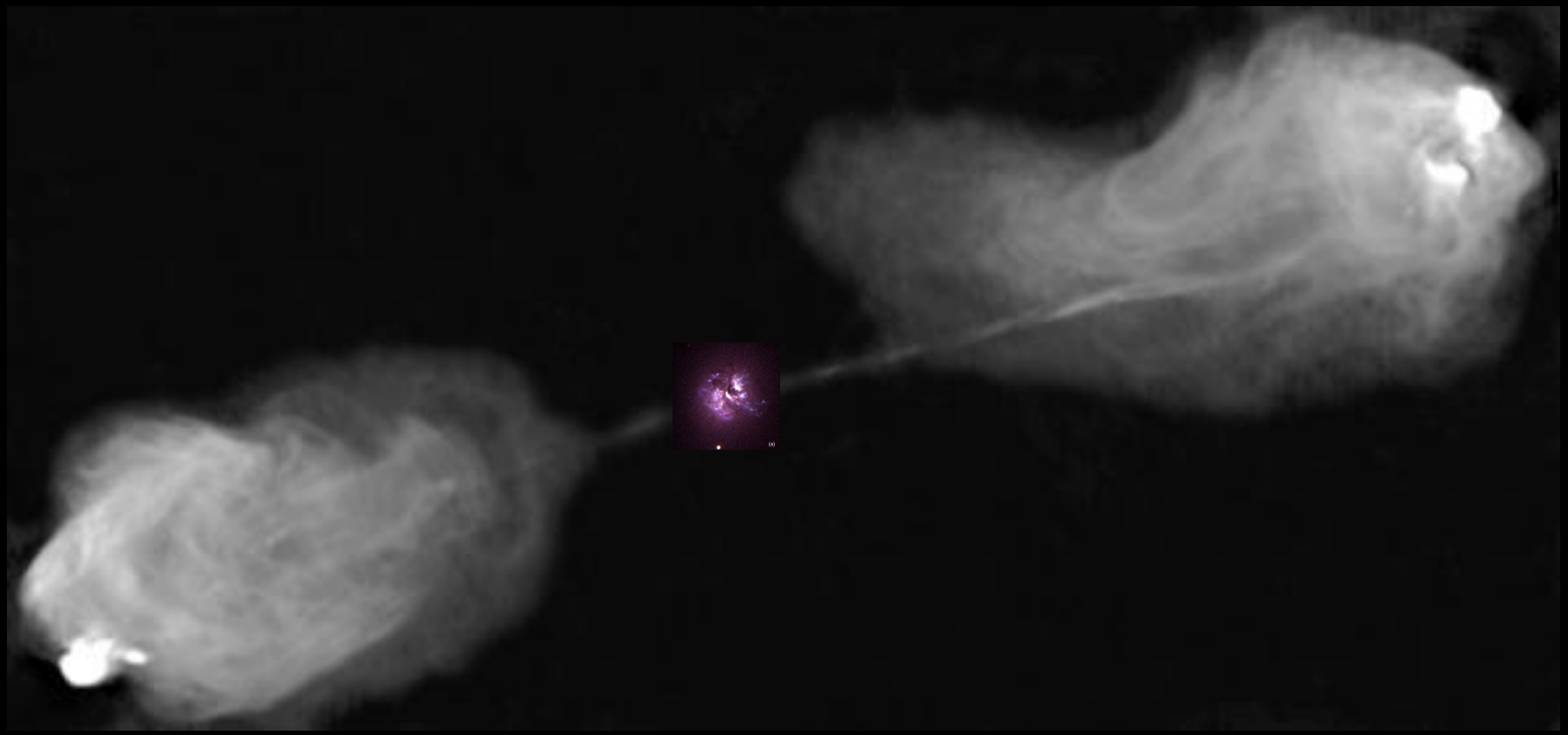
An optical image showing the galaxies as two fuzzy blobs superimposed on the VLA radio image showing the radio jets.

Z = 0.023 => 320 million lyr



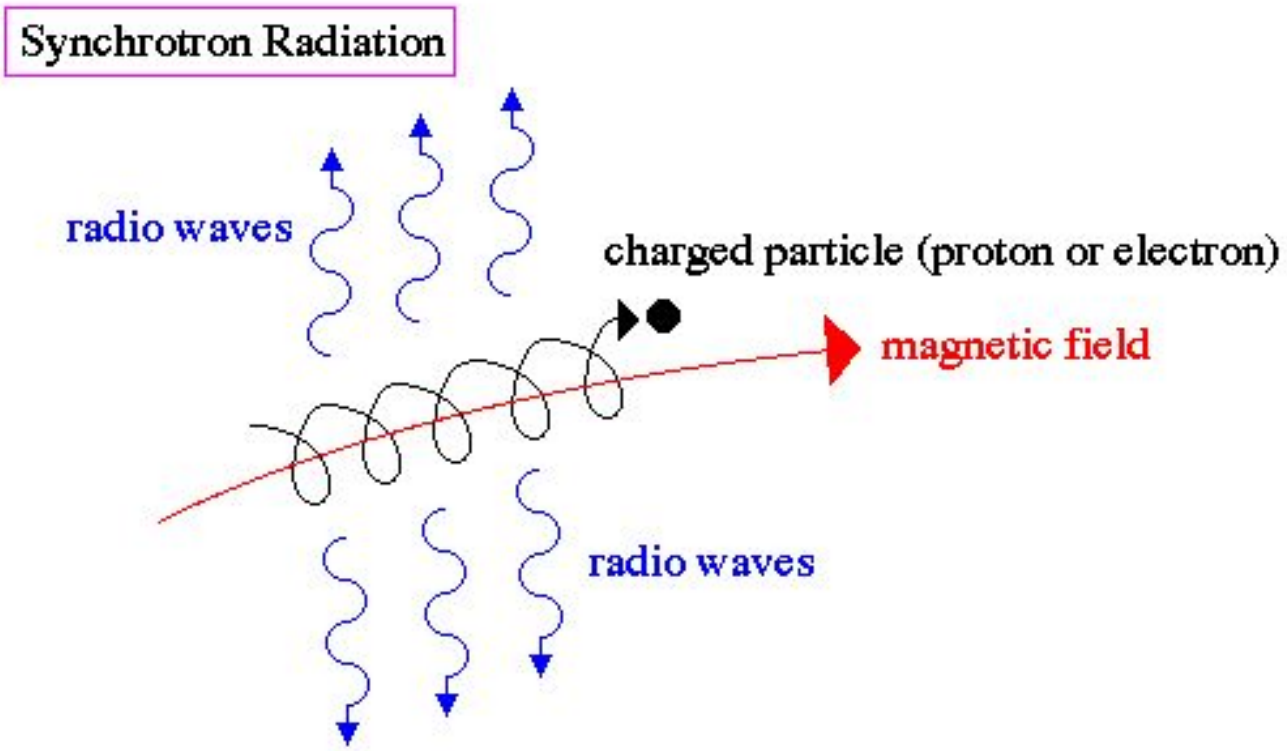
Cygnus A: one of the largest radio galaxies in the Universe

500,000 light years



Z = 0.056

Radio galaxies shine by emitting *synchrotron radiation*



synchrontron 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

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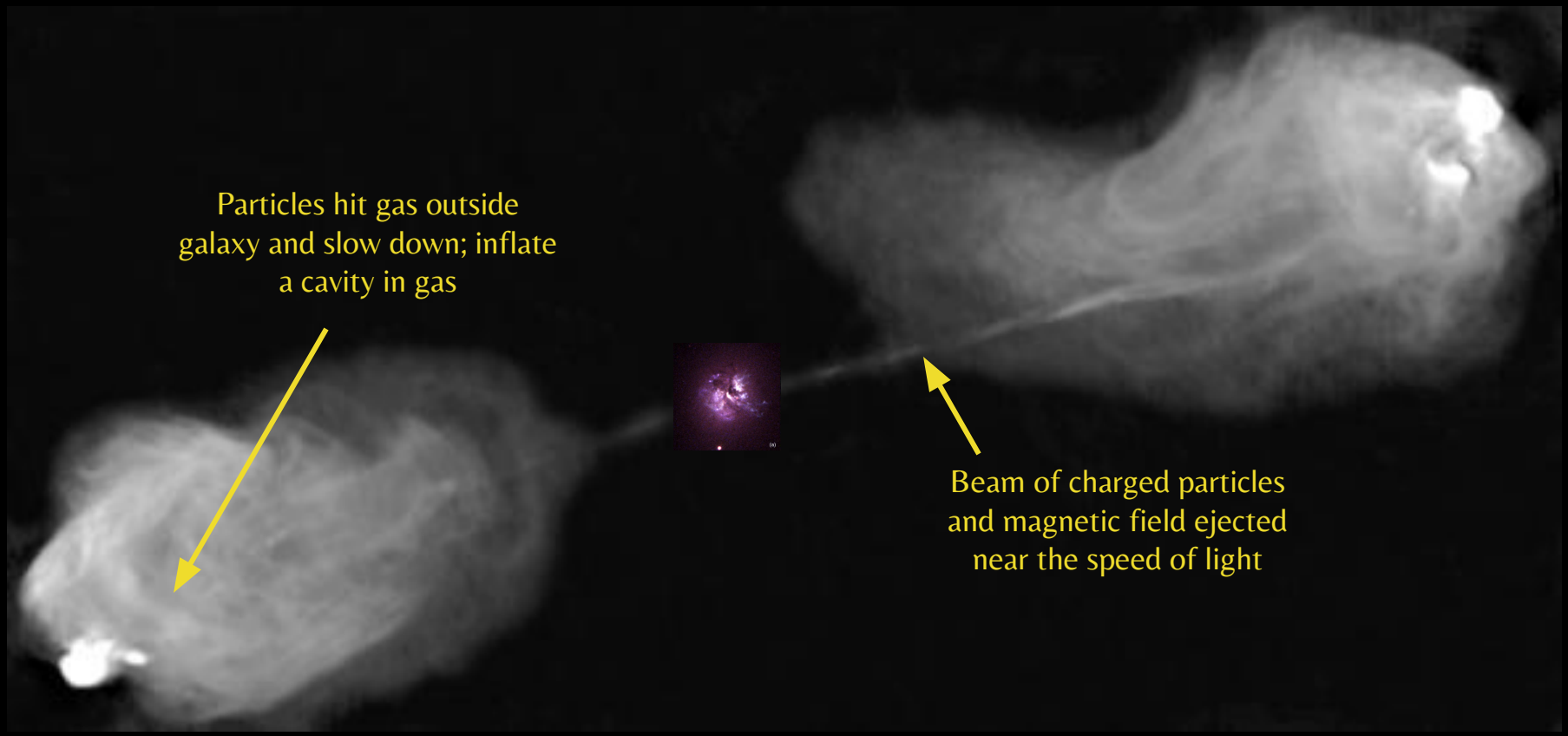
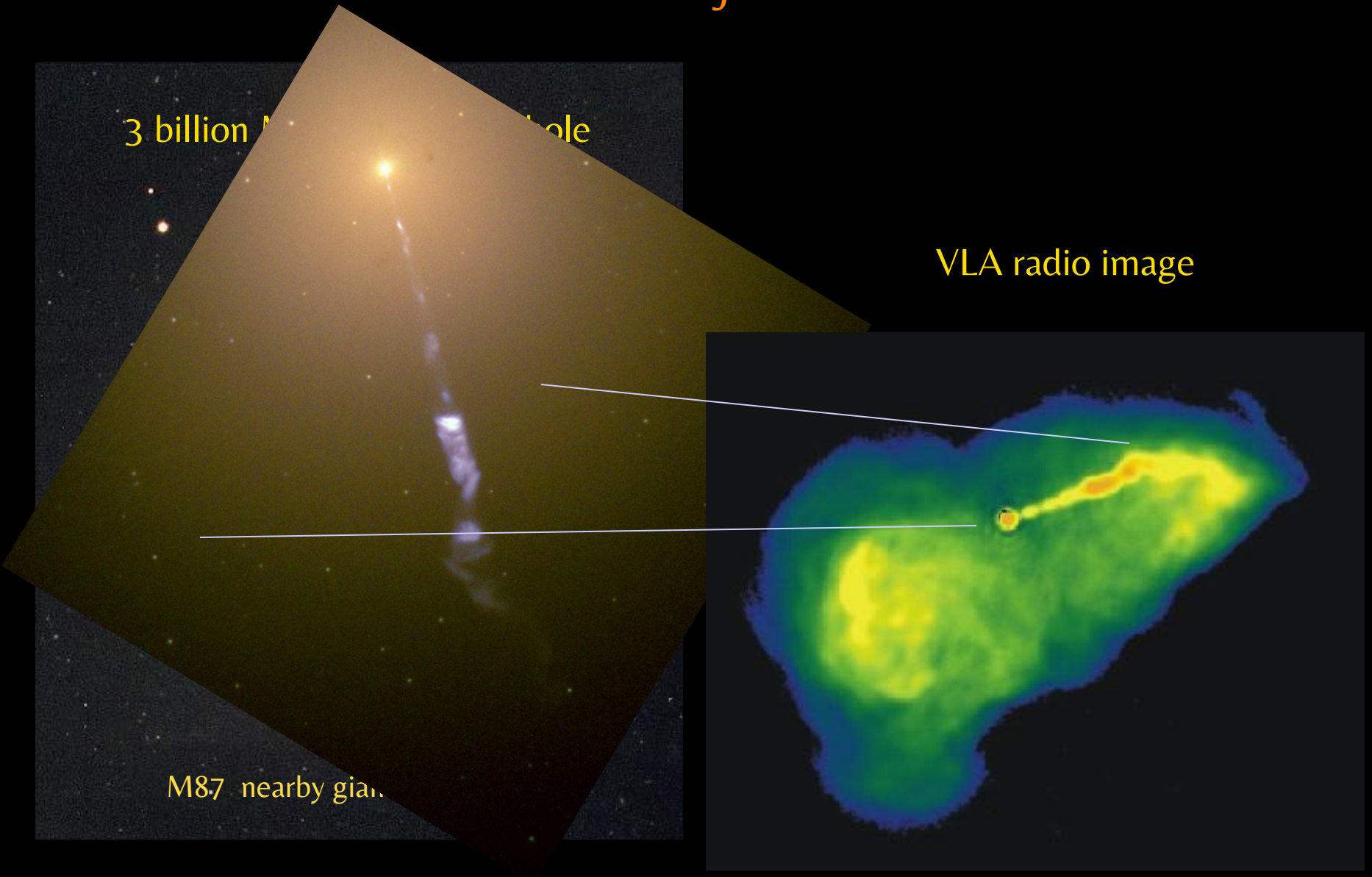
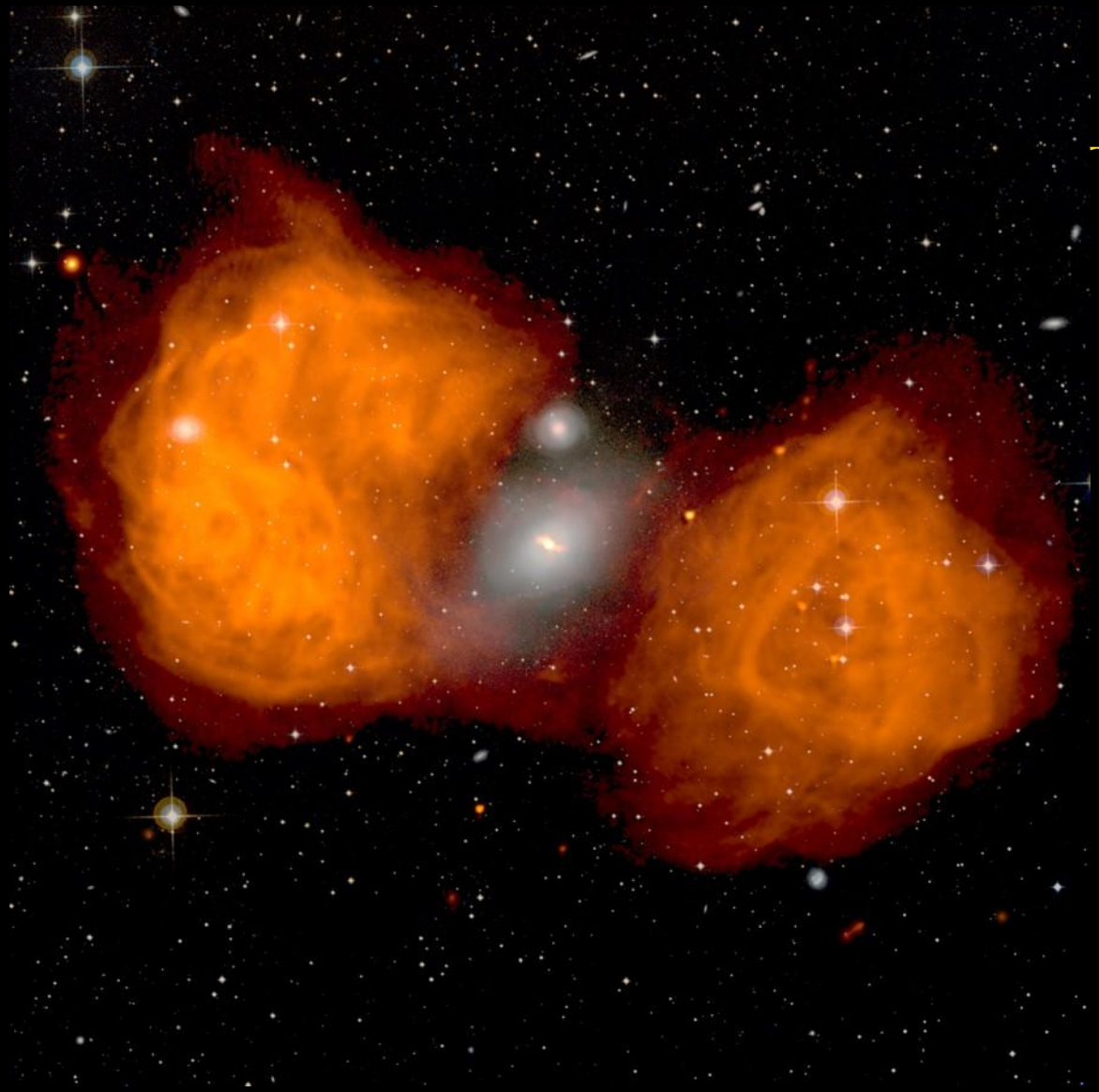


Z = 0.056

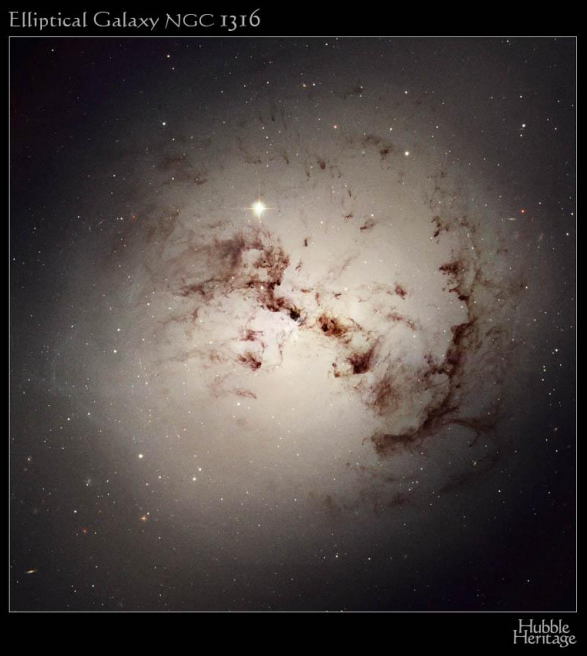
M87: A nearby giant elliptical galaxy with central AGN and radio “jet”



Weaker radio galaxies have “fluffier” radio lobes



The peculiar nearby elliptical NGC 1316 with radio lobes



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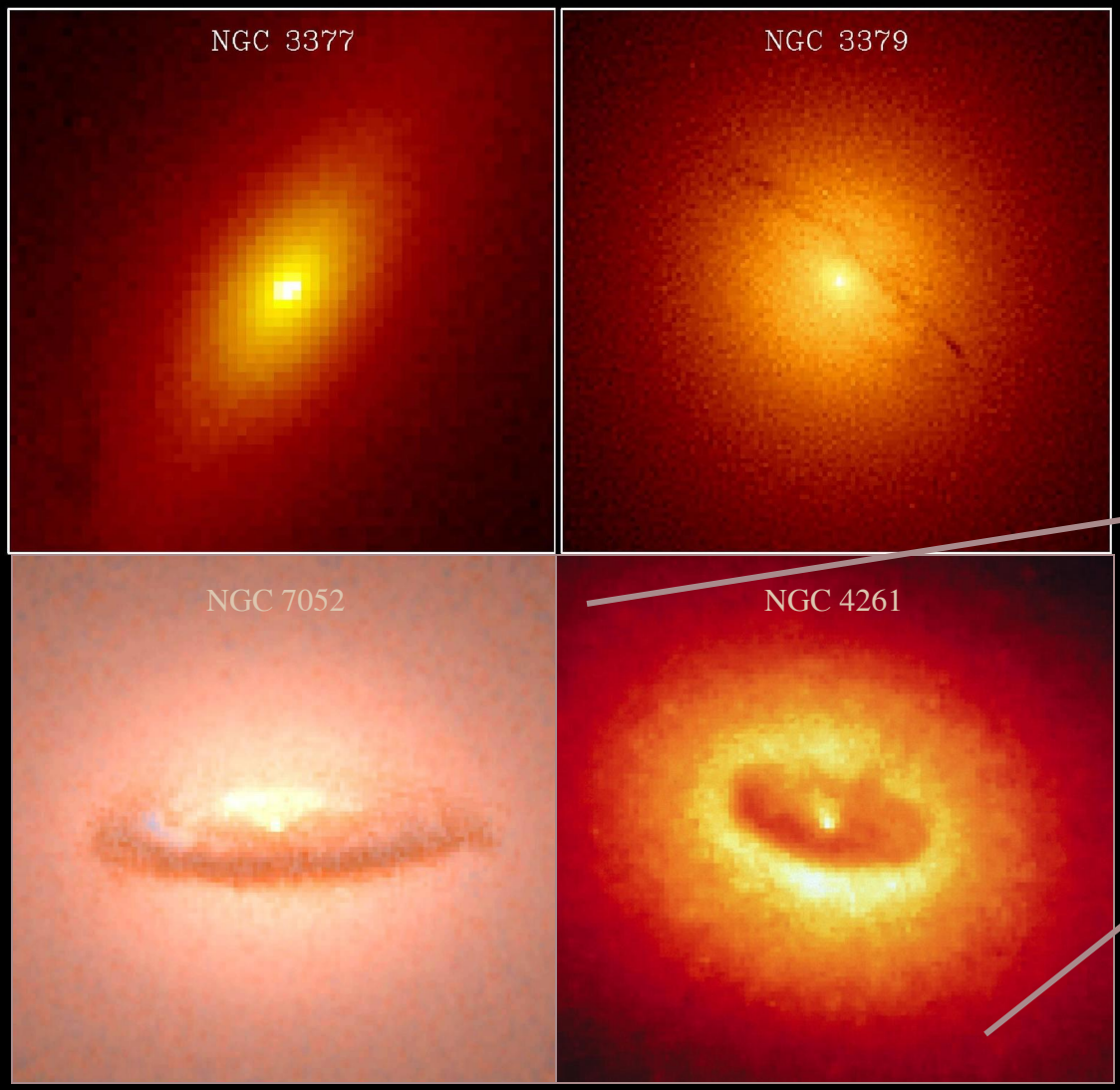
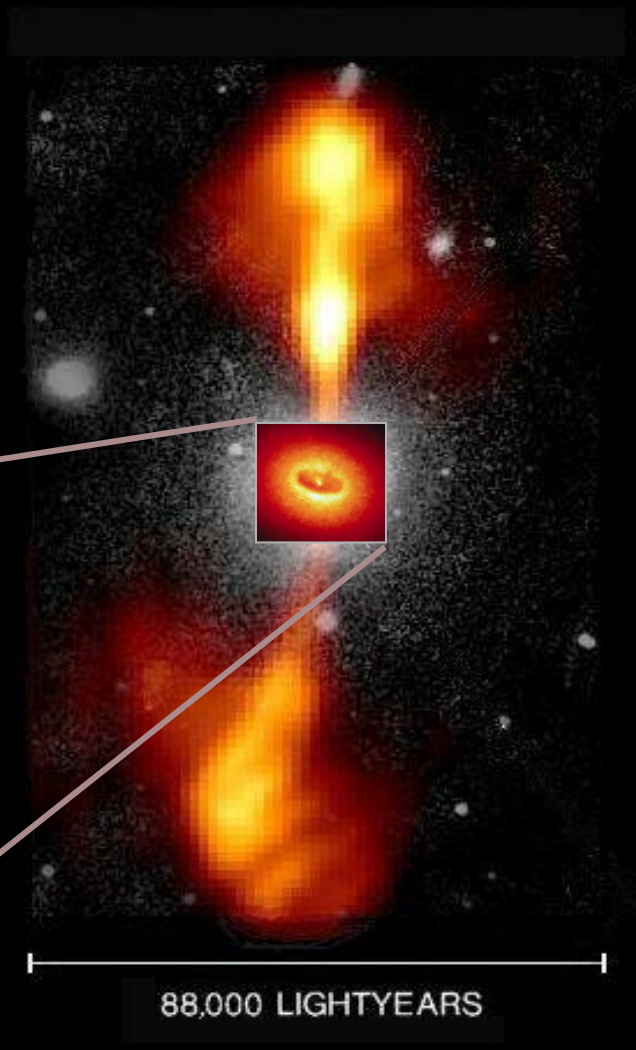
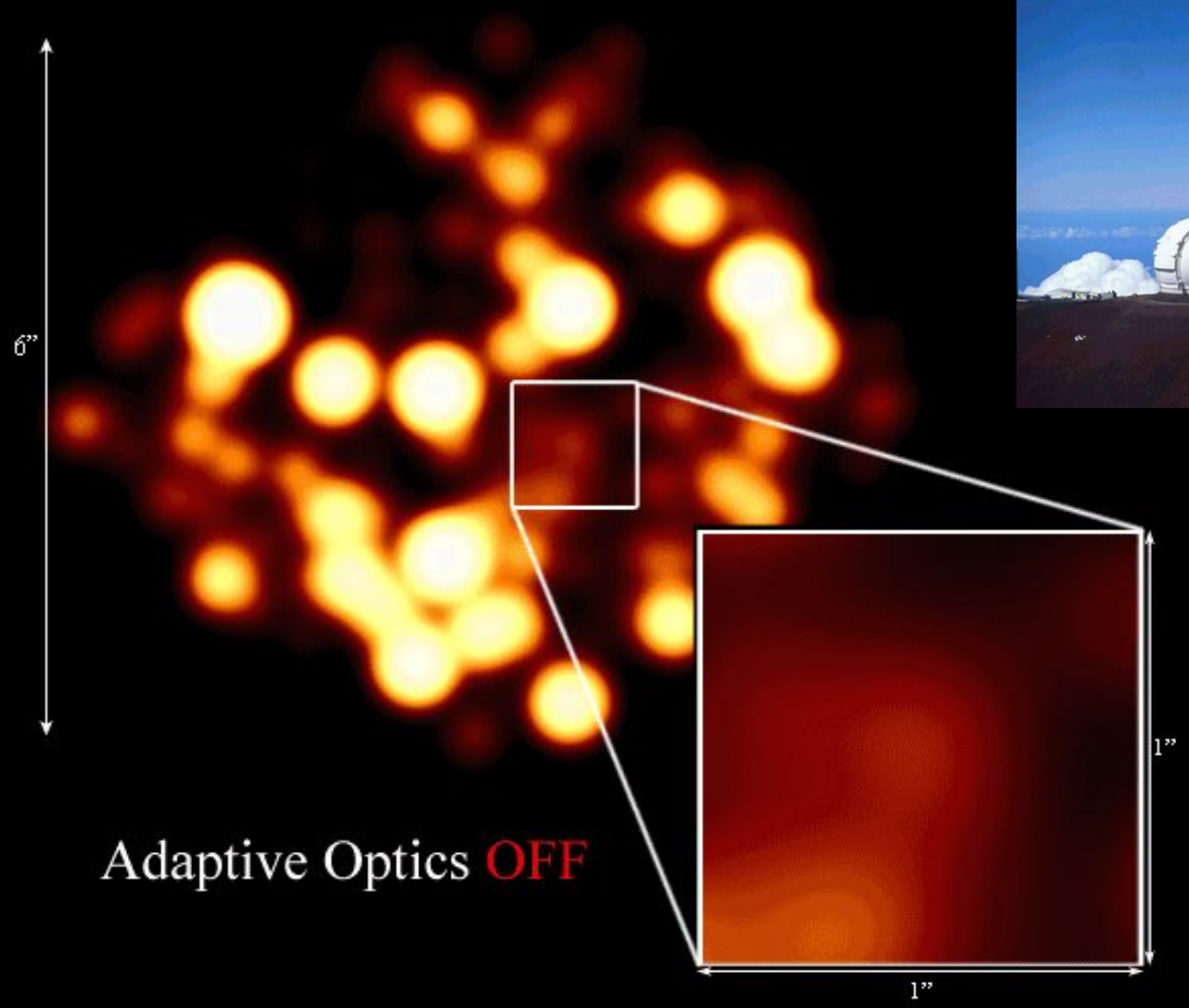
Spheroids host massive central black holes, which power quasars and other kinds of active galactic nuclei (AGNs)



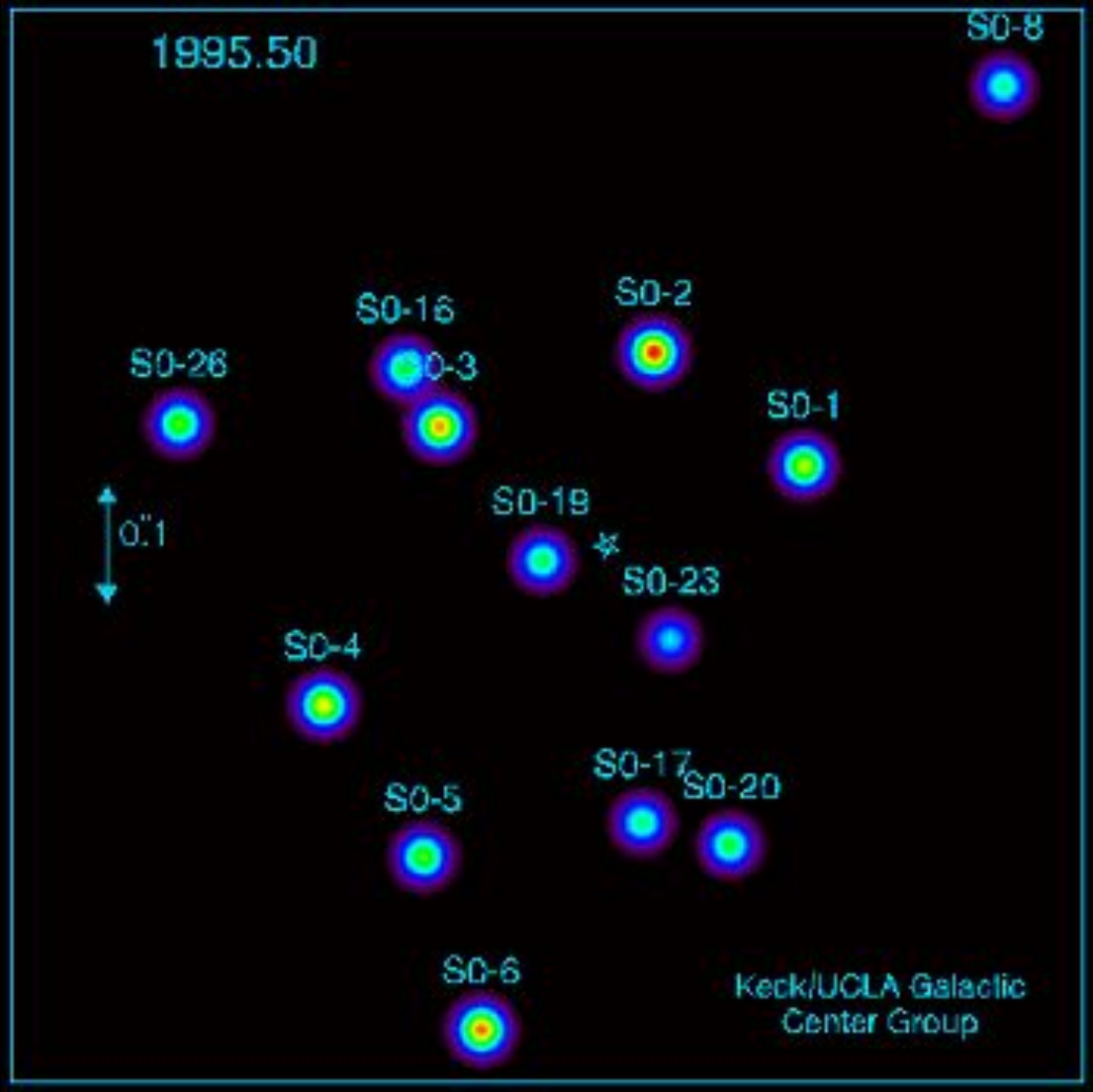


Our Milky Way observed with *adaptive optics* at the 10-meter Keck telescope

The Galactic Center at 2.2 microns



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



3-d movie of orbiting stars at center of MW