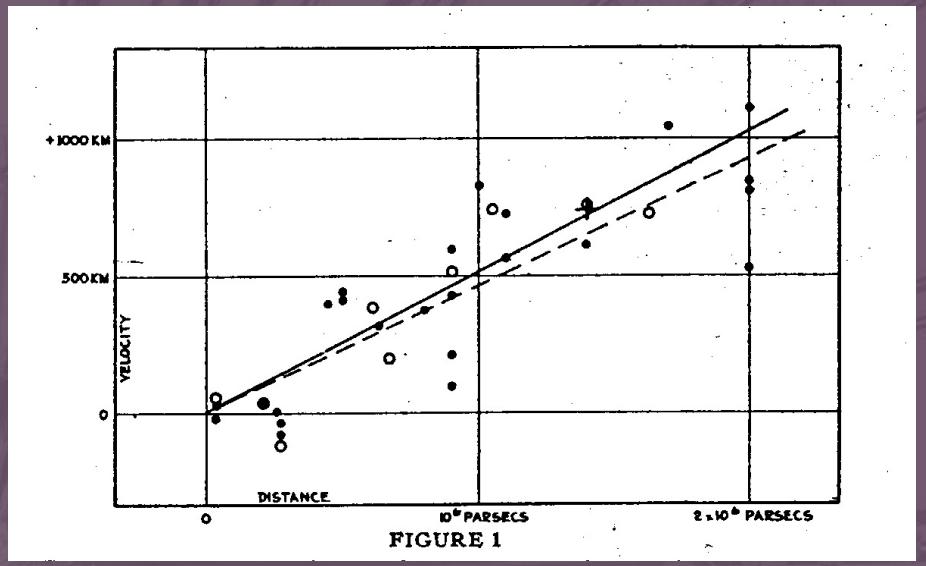
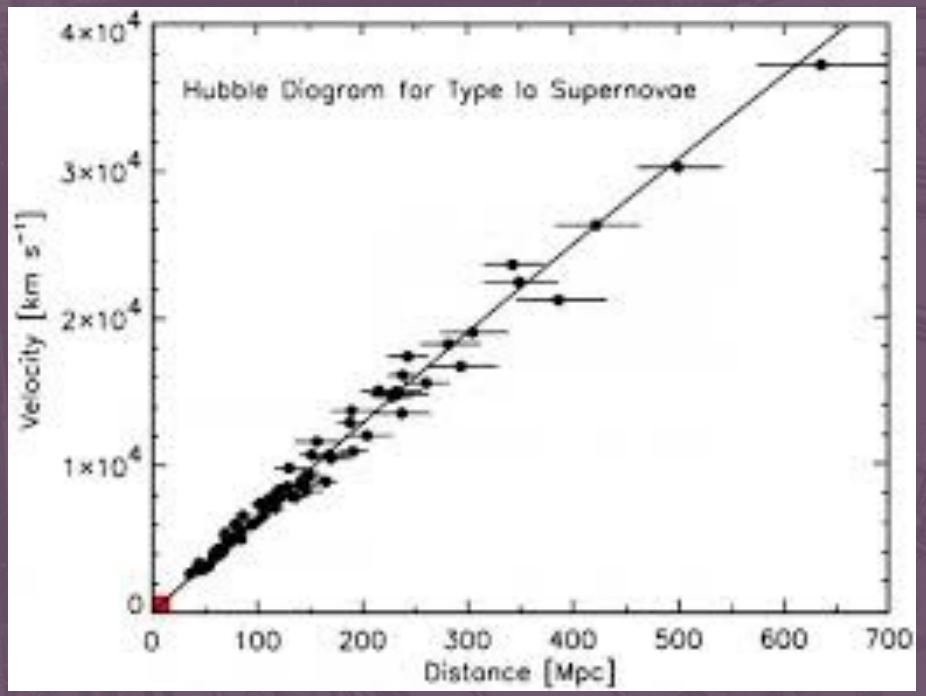
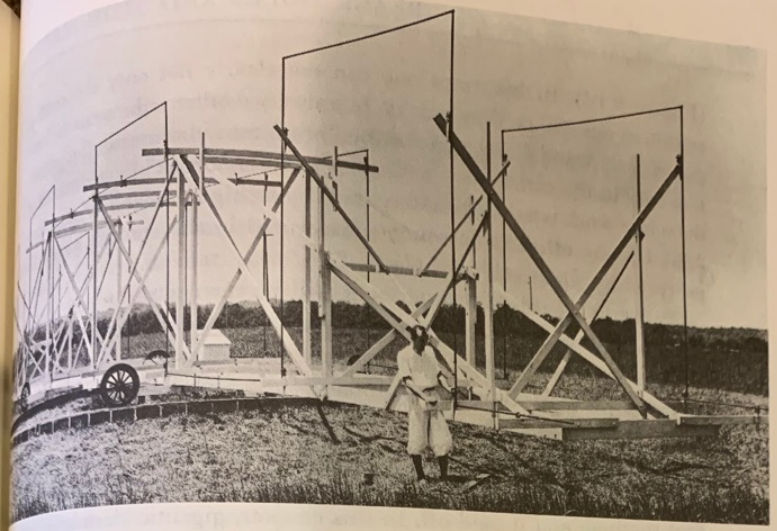
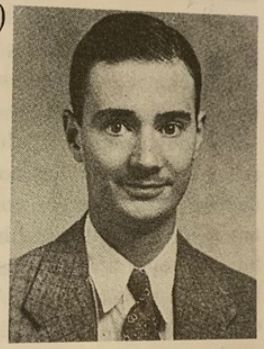

+1000 KM
500 KM
0
VELOCITY
DISTANCE
0
10⁶ PARSECS
2 x 10⁶ PARSECS
FIGURE 1


Hubble Diagram for Type Ia Supernovae
Velocity [km s⁻¹]
4×10⁴
3×10⁴
2×10⁴
1×10⁴
0
0
100
200
300
400
500
600
700
Distance [Mpc]

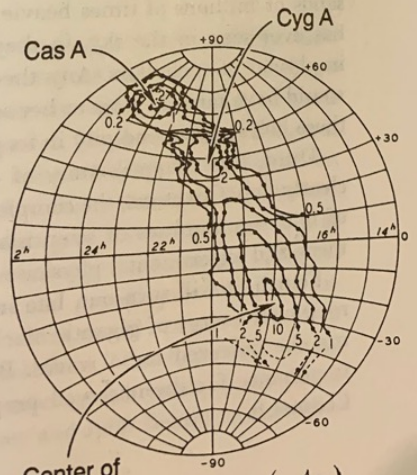


(a)

(b)



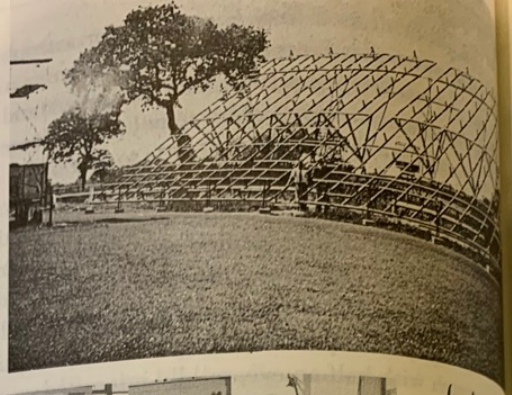
(c)


Cas A
Cyg A
+90
+60
+30
0
-30
-60
-90
0.2
0.2
2
0.5
0.5
2h
24h
22h
18h
14h
10
5
2
1
Center of
our galaxy

(d)

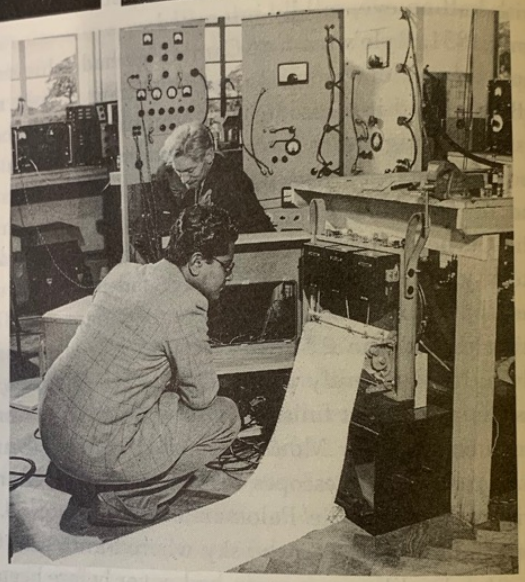
Centaurus A Radio Galaxy (VLT KUEYEN + FORS2)

ESO PR Photo 05h/00 (8 February 2000)

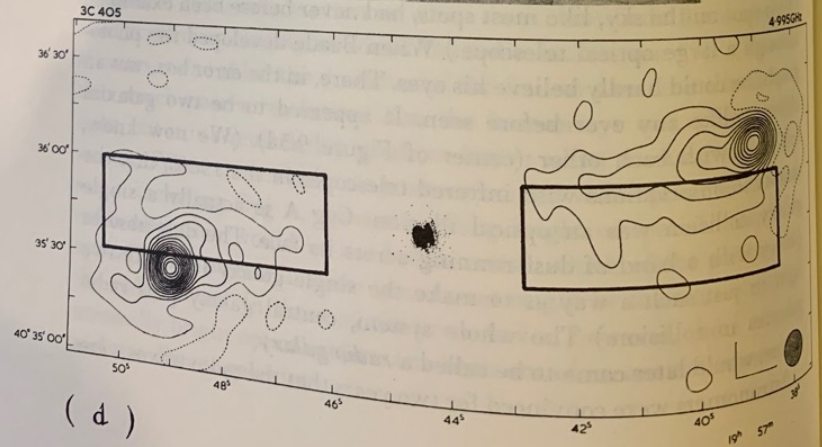


(a)

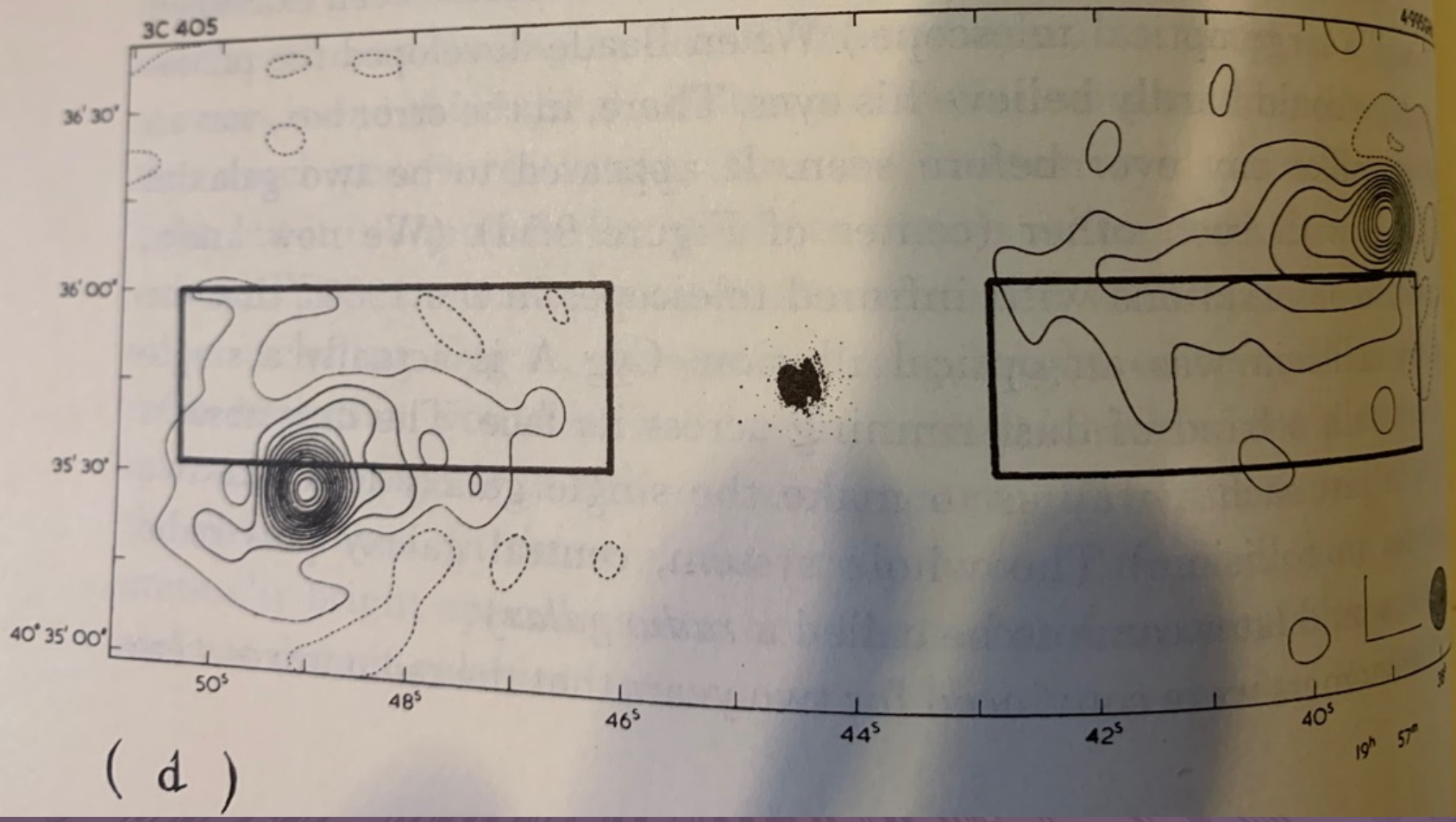
(b)



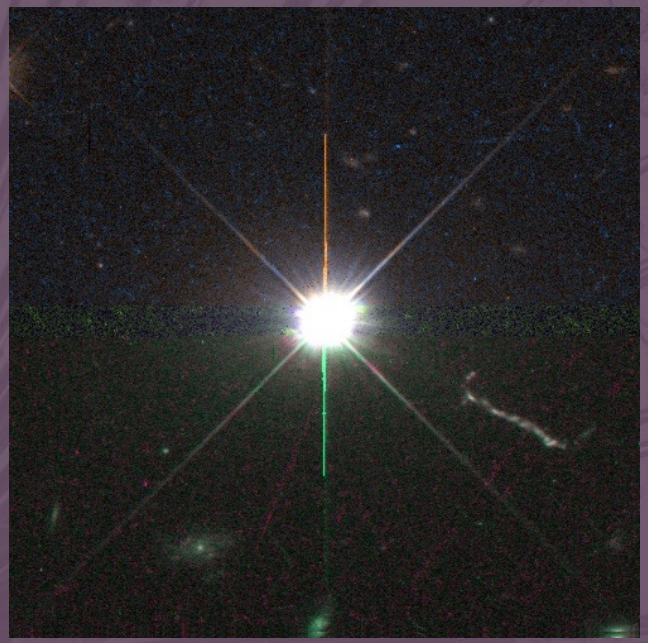
(c)

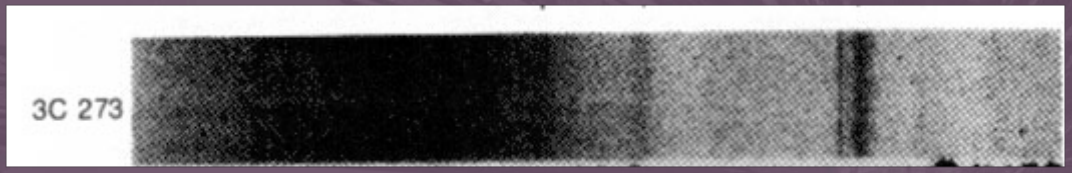

3C 405
4995GH
36' 30"
36' 00"
35' 30"
40° 35' 00"
50s
48s
46s
44s
42s
40s
38s
19h 57m

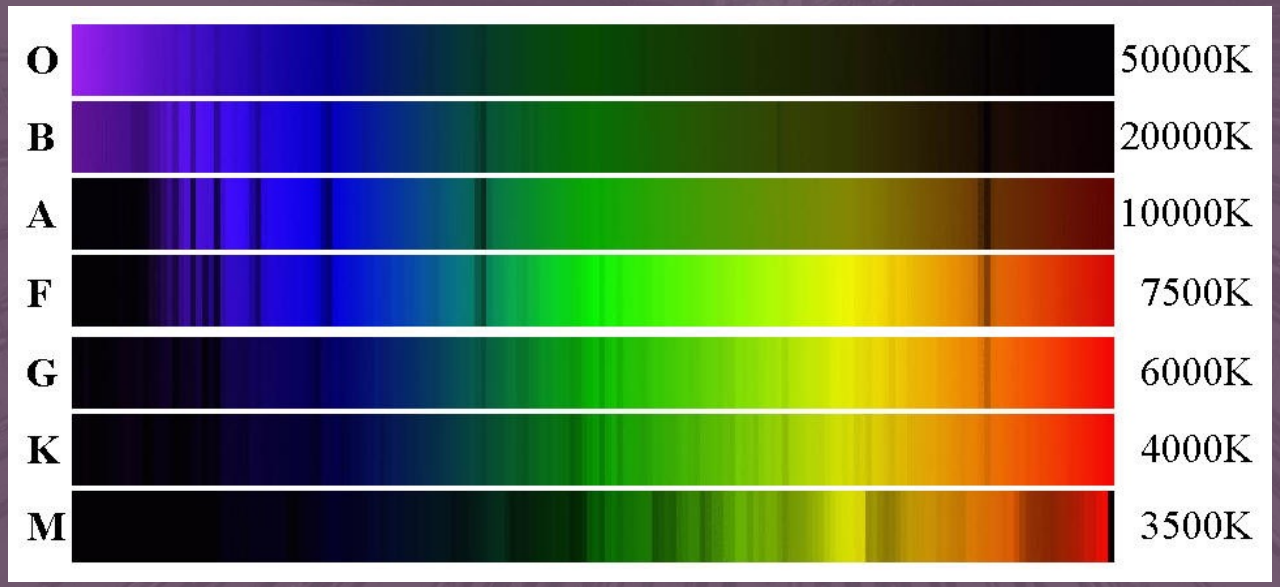
(d)

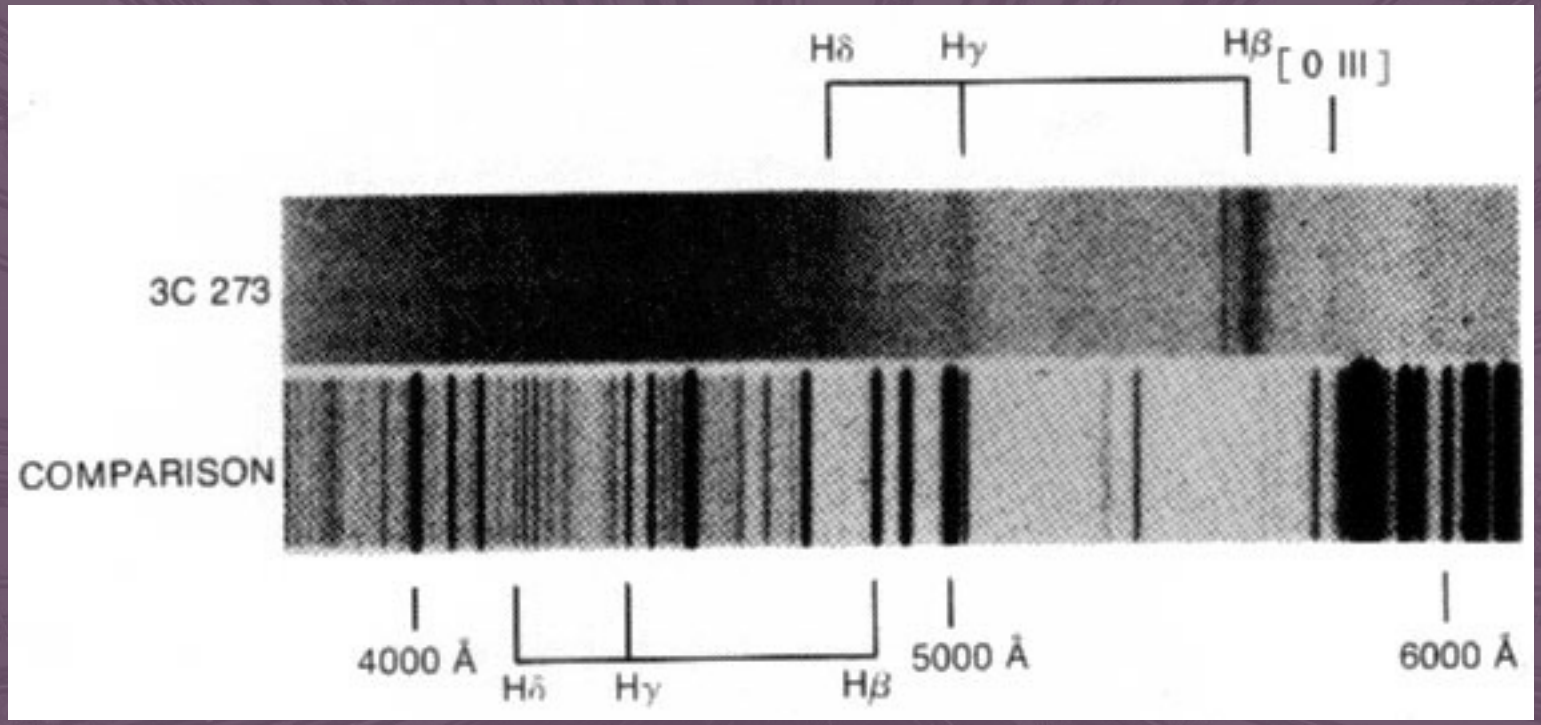


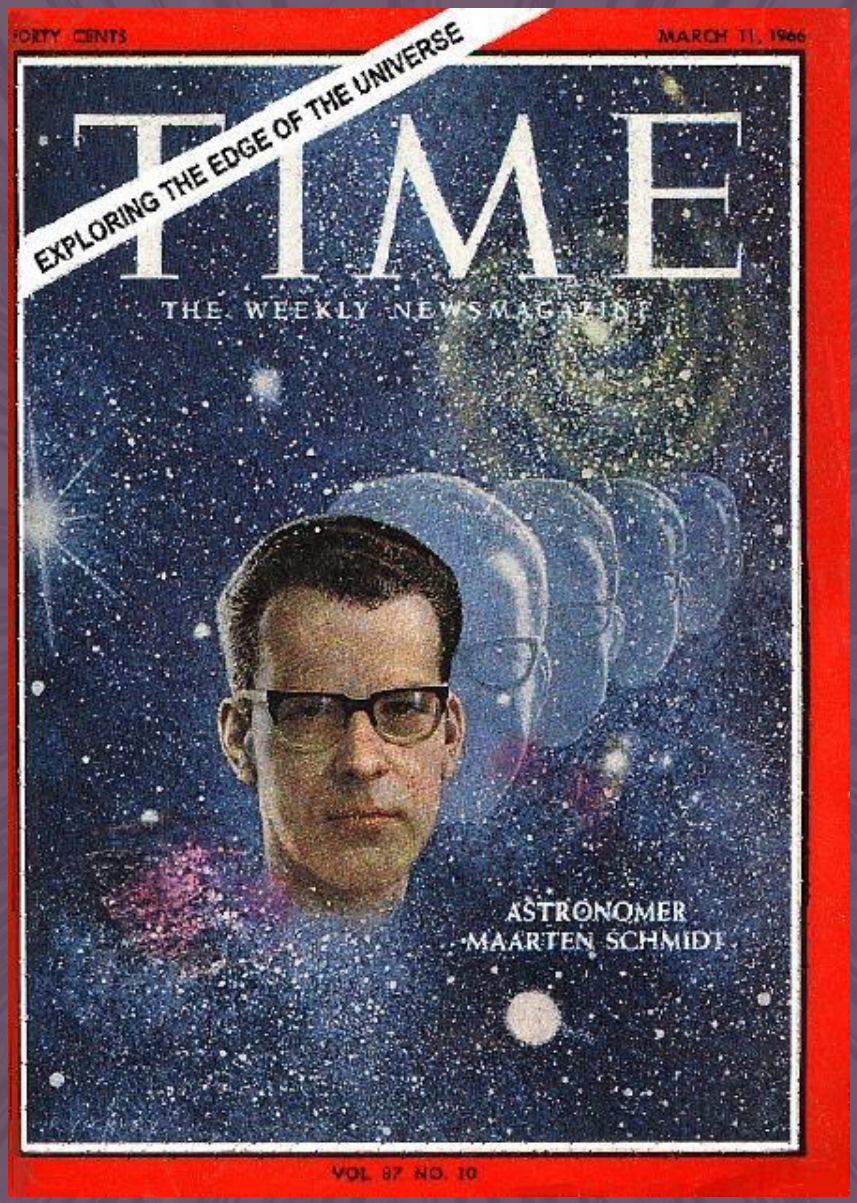
(d)

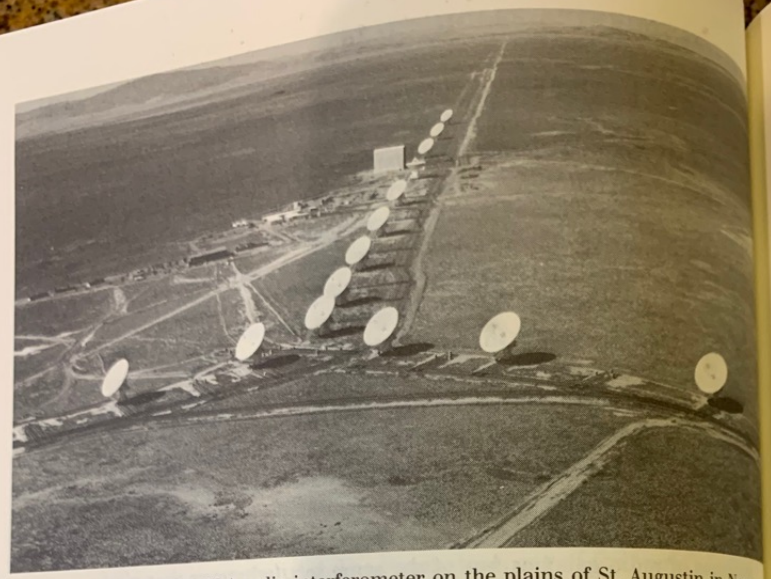



3C 273

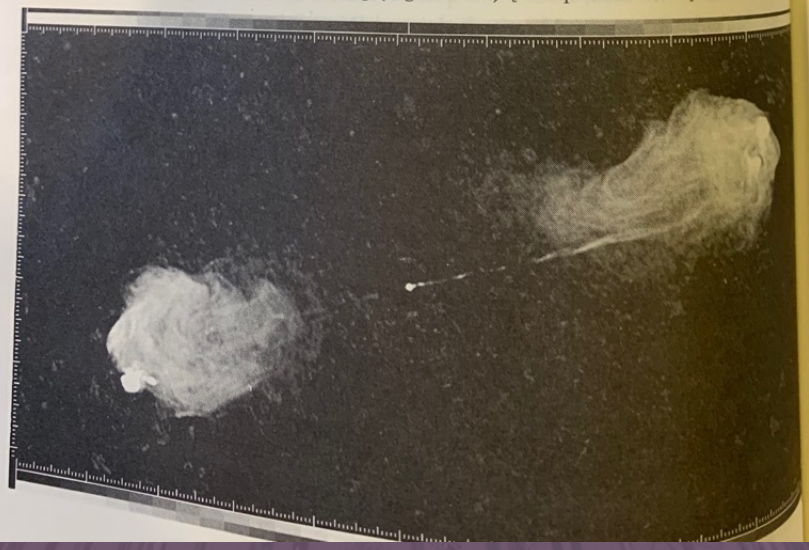

O
50000K
B
20000K
A
10000K
F
7500K
G
6000K
K
4000K
M
3500K


Hδ
Hγ
Hβ
[O III]
3C 273
COMPARISON
4000 Å
Hδ
Hγ
Hβ
5000 Å
6000 Å


FORTY CENTS
MARCH 11, 1966
EXPLORING THE EDGE OF THE UNIVERSE
TIME
THE WEEKLY NEWSMAGAZINE
ASTRONOMER
MAARTEN SCHMIDT
VOL. 87 NO. 10



9.5 *Top:* The VLA radio interferometer on the plains of St. Augustin in New Mexico. *Bottom:* A picture of the radio emission from the radio galaxy Cygnus A made with the VLA by R. A. Perley, J.W. Dreyer, and J.J. Cowan. The jet that feeds the right-hand radio lobe is quite clear; the jet feeding the left lobe is much fainter. Notice the enormous improvement in resolution of this radio-wave picture compared with Reber's 1944 contour map which did not show the double lobes at all (Figure 9.1d), and with Jennison and Das Gupta's 1953 radio map which barely revealed the existence of the lobes (two rectangles in Figure 9.3d), and with Ryle's 1969 contour map (Figure 9.3d). [Both pictures courtesy NRAO/AUL]



interferomete
much larger
telescopes). It
same as the w
when one co
instruments
there. By the
quasars, with
were being
composed of
world. (The
tape, along
from all the
"interfered"

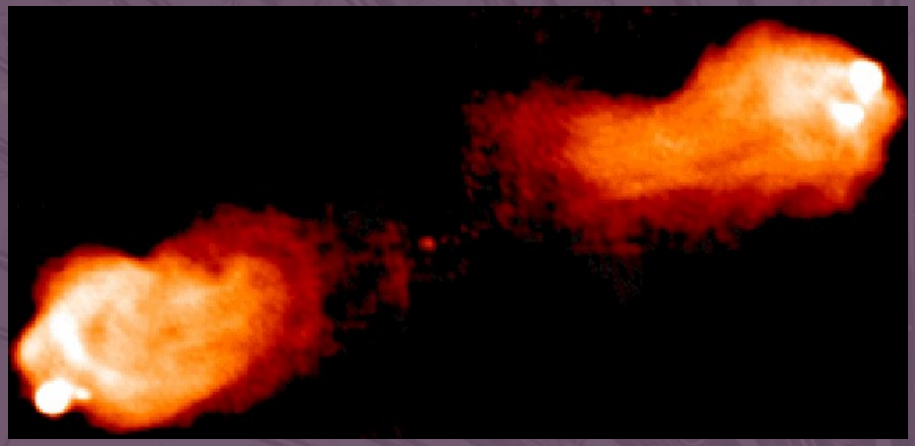
These VL
right into t
quasar—th
such as 3C2
than a light
light-emitt
the jets, wh

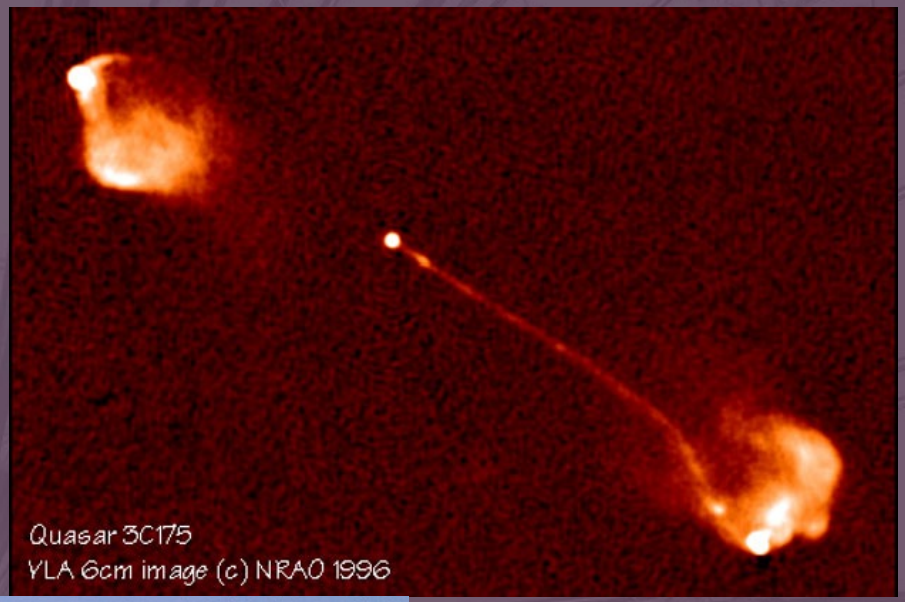
The jets
Some jets
years or m
rotating w
observed j
firing its j
long? Sinc
since som
firing dire
To achiev
must be a
some sort
holds the
Such gyr
airplanes

Of the
explain t
long life
powerfu

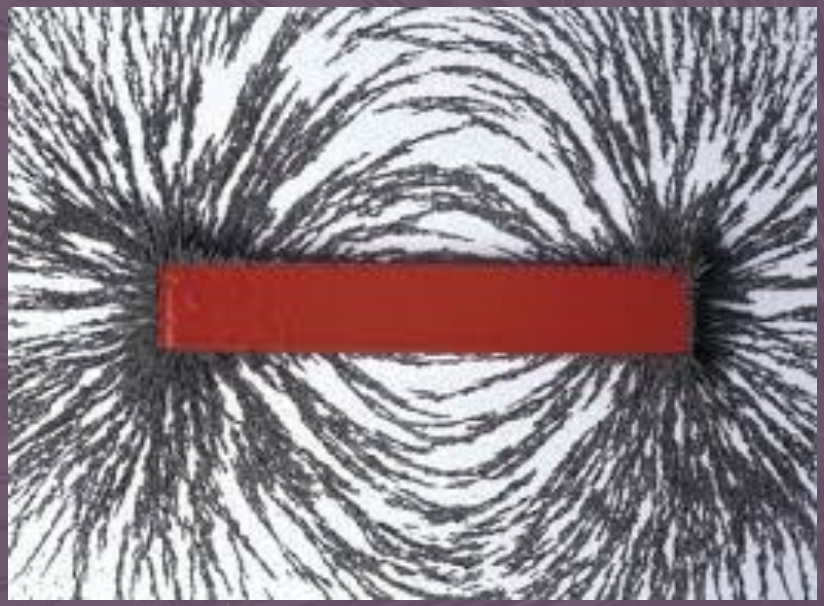
The Very Large Array

Cygnus A' (optical and radio)

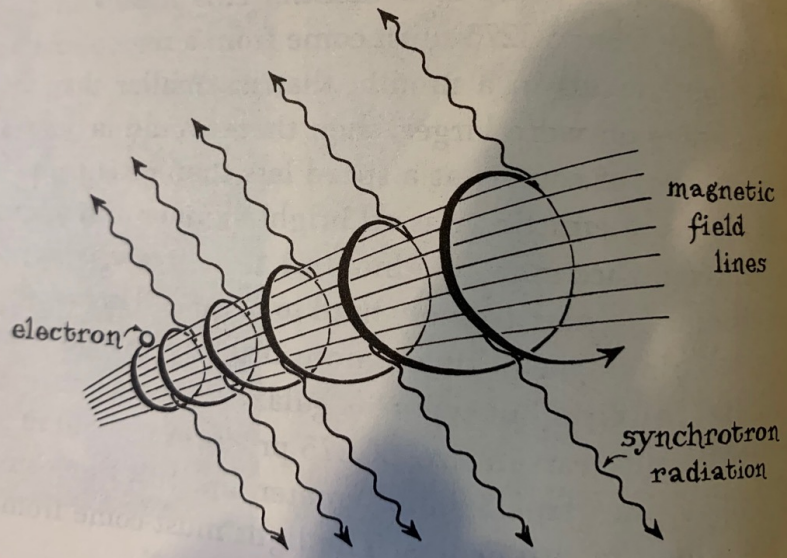


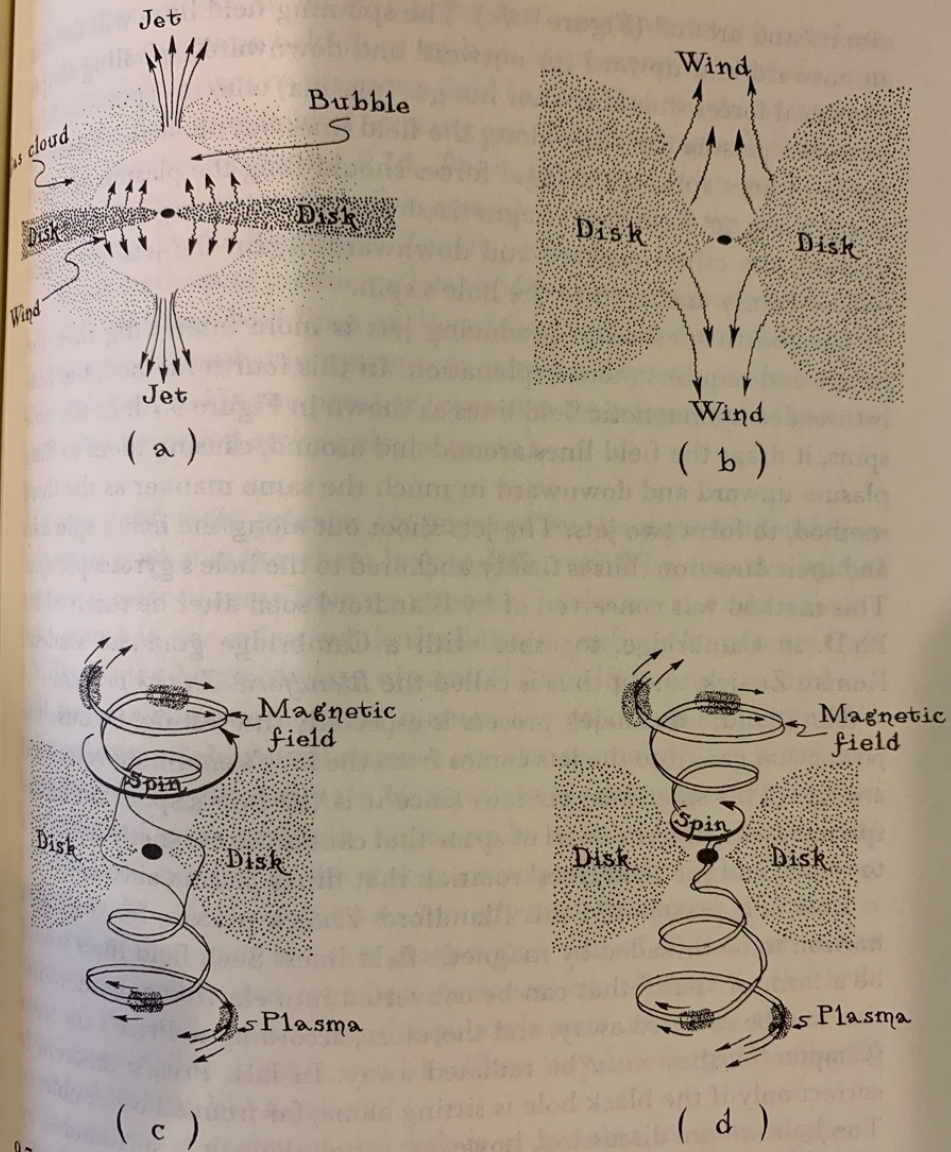

Quasar 3C175
VLA 6cm image (c) NRAO 1996

Quasi-stellar Radio Source (Quasar)

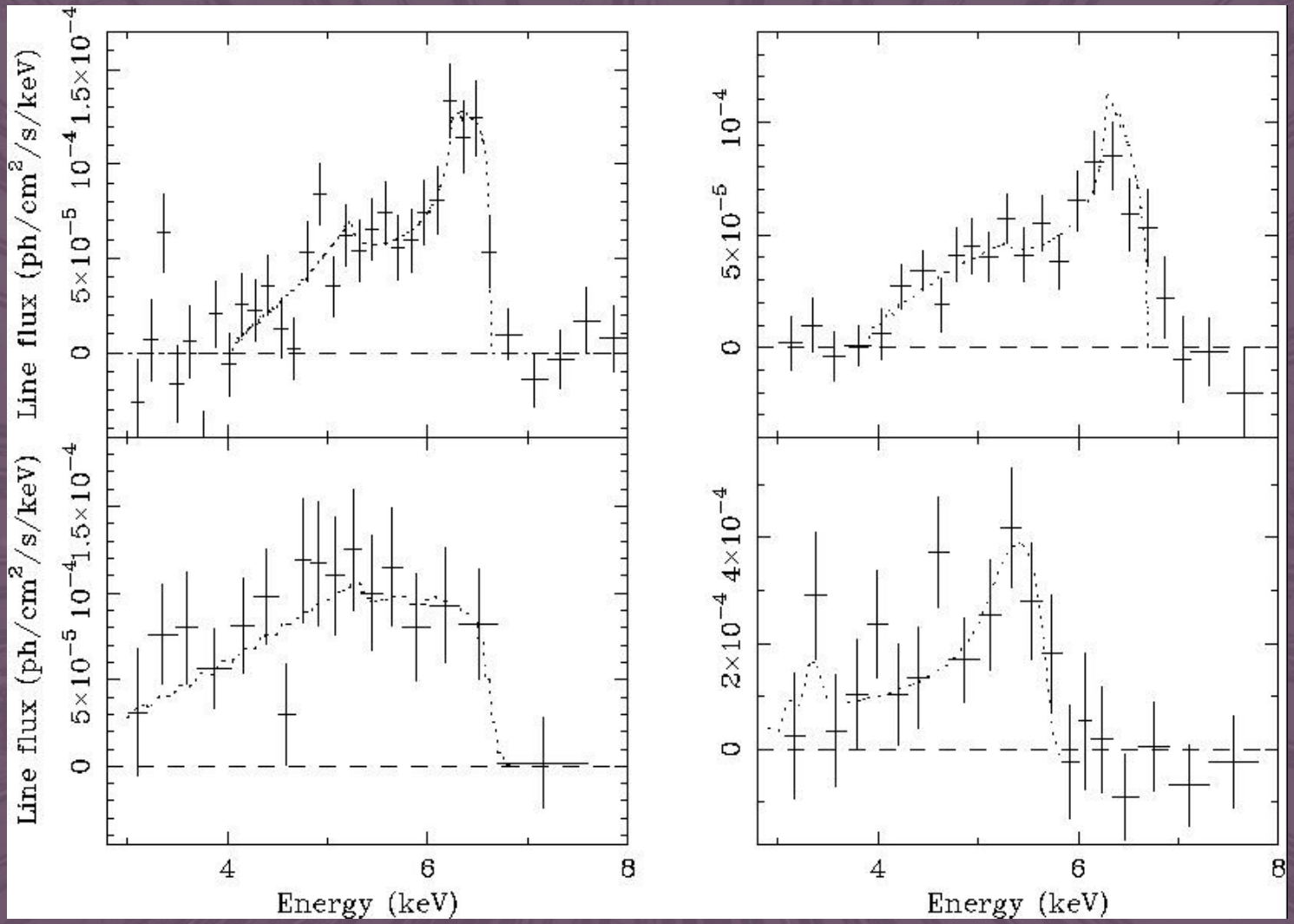


9.4 Cosmic radio waves are produced by near-light-speed electrons that spiral around and around in magnetic fields. The magnetic field forces an electron to spiral instead of moving on a straight line, and the electron's spiraling motion produces the radio waves.

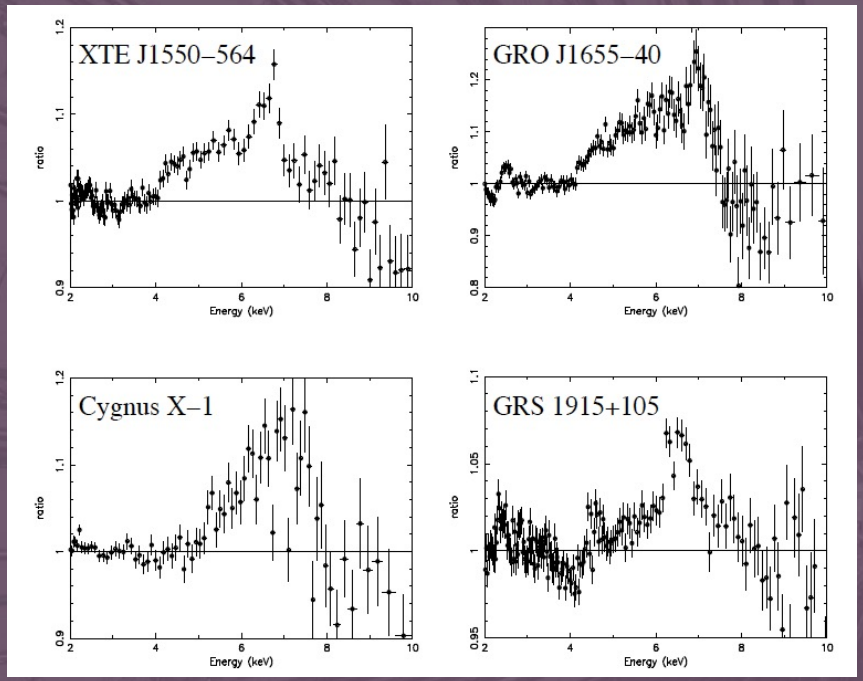




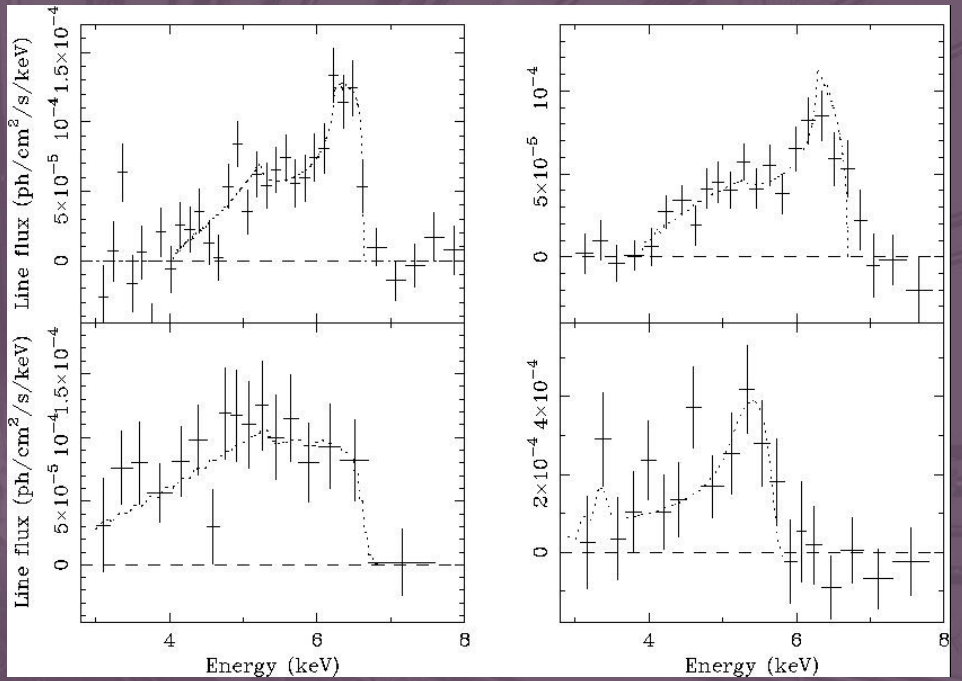
9.7 Four methods by which a black hole or its accretion disk could power twin jets. (a) A wind from the disk blows a bubble in a surrounding, spinning gas cloud; the bubble's hot gas punches orifices through the cloud, along its spin axis; and jets of hot gas [illegible] (b) The disk is puffed up by the pressure of its



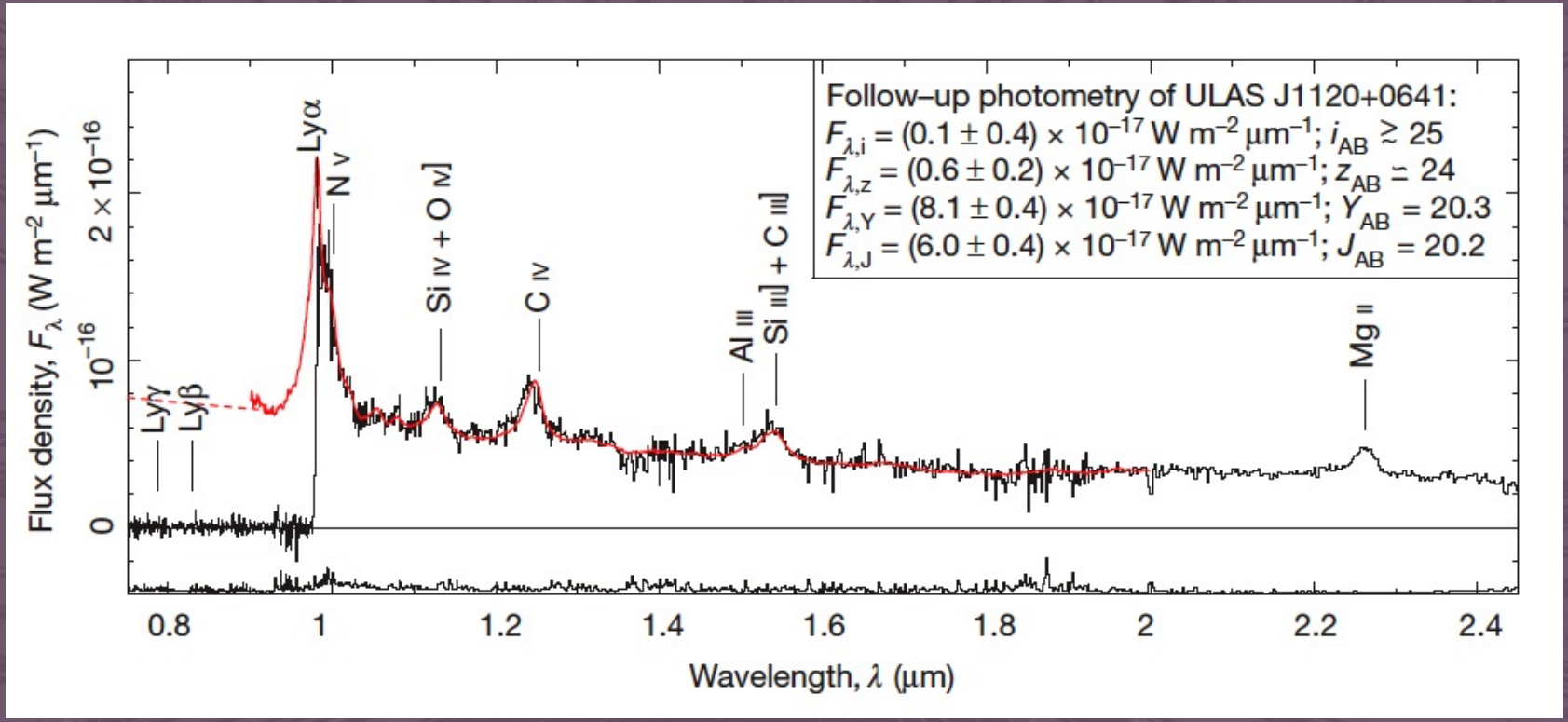
X-ray iron lines from nearby quasars



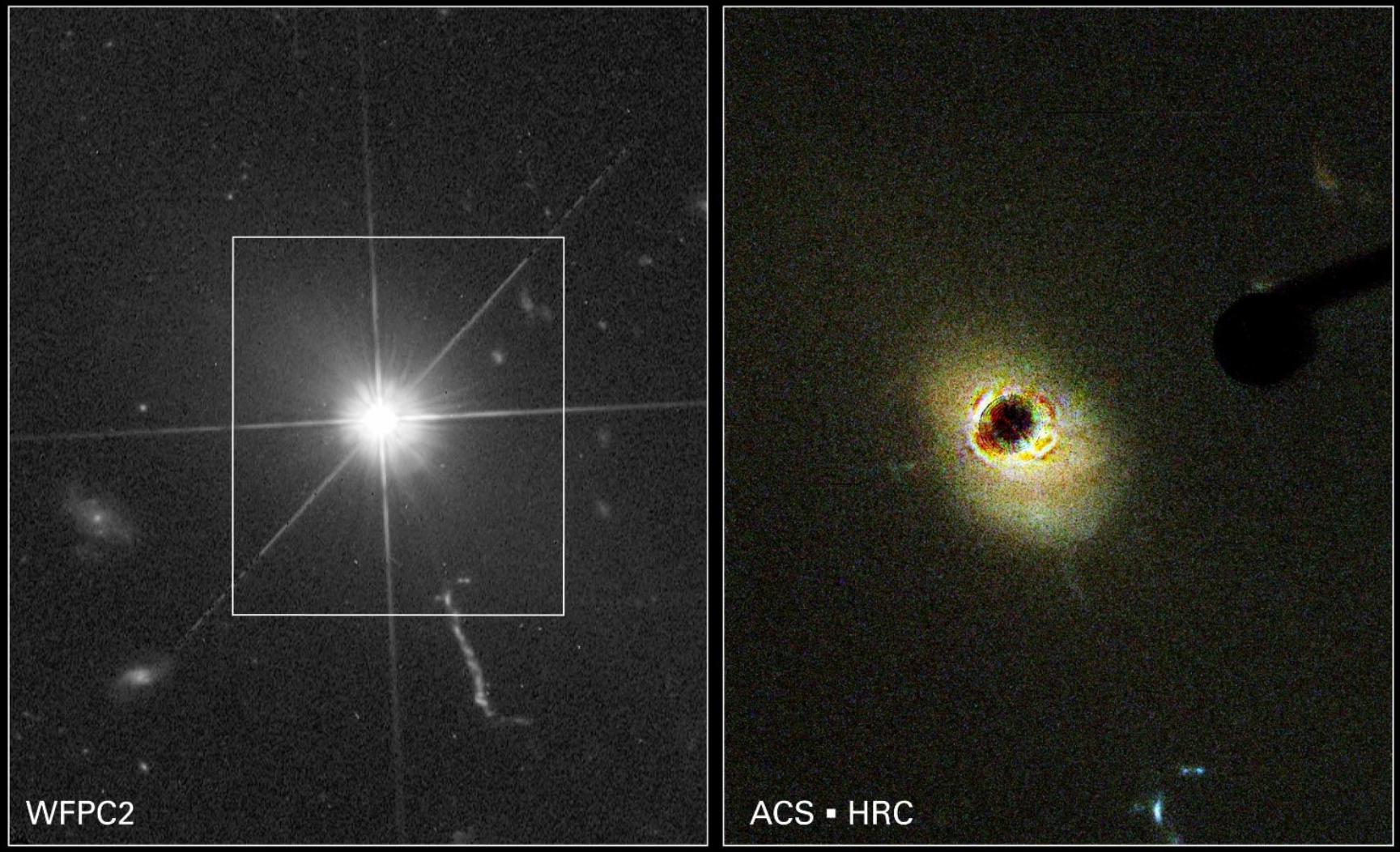
Stellar mass black holes in the Milky Way



Supermassive black holes in nearby quasars



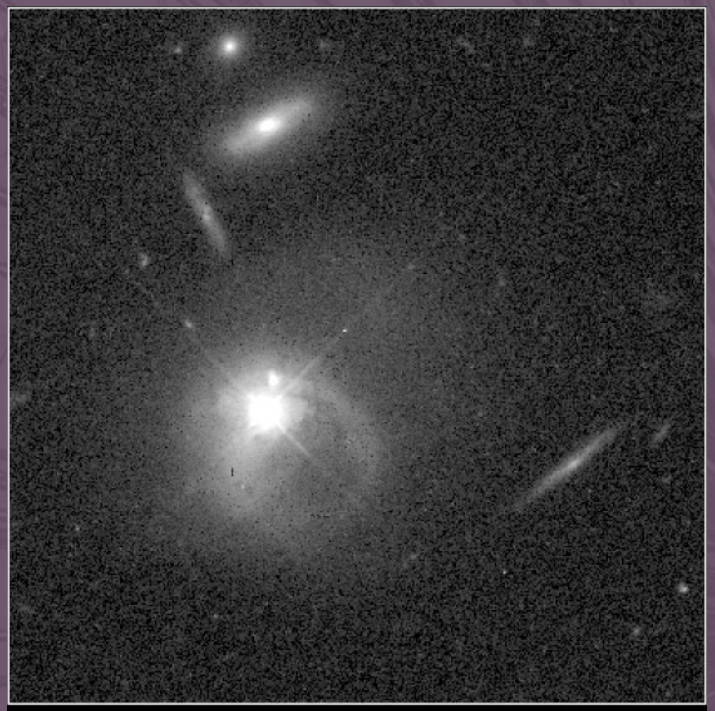
One of the most distant known quasars. Its light was emitted when the universe was 800 million years old (compared to 14 billion today), and expansion of the universe has stretched the wavelengths by a factor of 8.



Quasar 3C 273

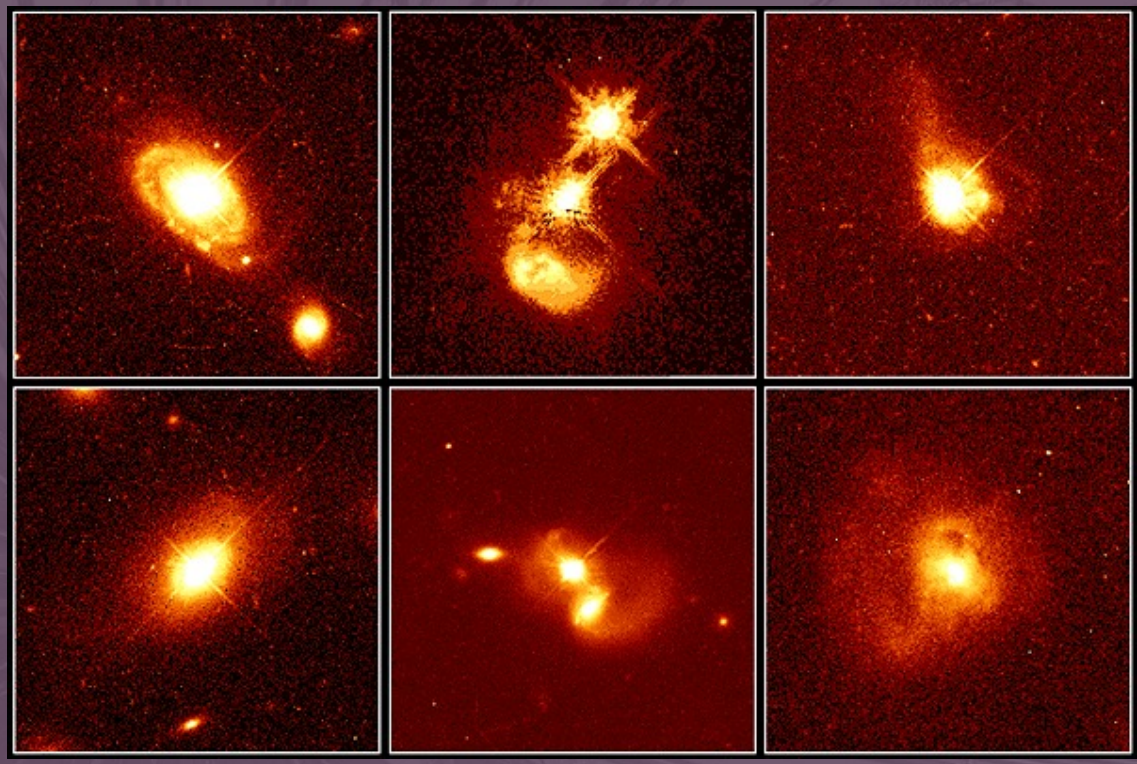
Hubble Space Telescope ▪ ACS HRC Coronagraph

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

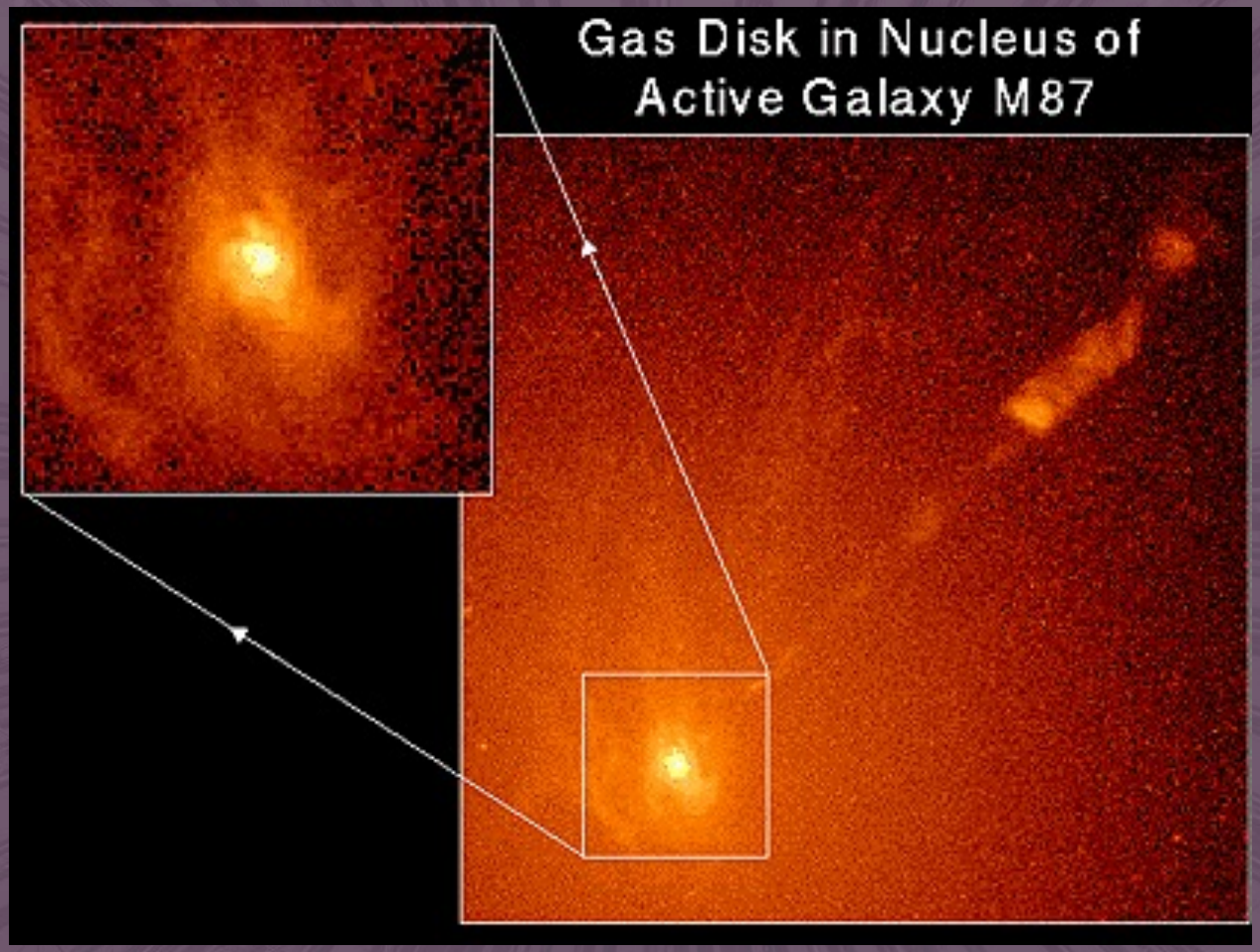


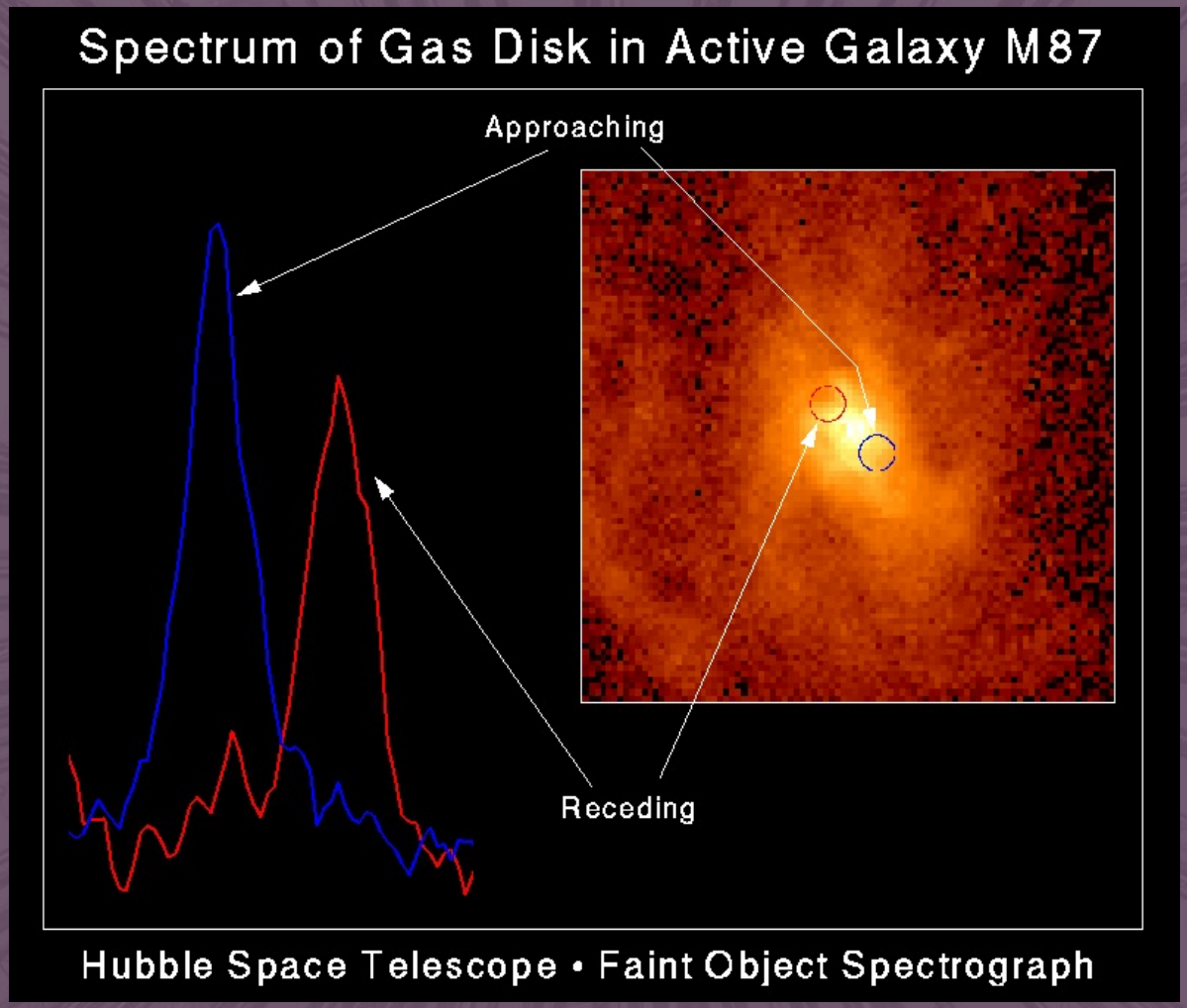
Quasar PKS 2349 HST • WFPC2

ST ScI OPO • January 1995 • J. Bahcall (Princeton), NASA



Messier 87


Gas Disk in Nucleus of
Active Galaxy M87


Spectrum of Gas Disk in Active Galaxy M87
Approaching
Receding
Hubble Space Telescope • Faint Object Spectrograph