Starbursts, Interacting Galaxies and Active Galactic Nuclei (AGNs)

Evidence for close encounters, collisions & mergers
Eruptions and explosions -- radio galaxies
active galaxies, AGNs
quasars
Galaxies in collision/interacting/mergers

The “Antennae”

Computer simulation – interacting pair
M51 – the Whirlpool and companion
Evidence for mergers

Ring of active star formation

Distant Galaxies (large lookback times) – forming via mergers
Sgr dwarf elliptical merging with Milky Way
The Local Group -- Andromeda (M31) and Milky Way
Numerous examples of computer simulations of the projected merger can be found on the Internet
Active Galaxies

Strong radio sources

Radio galaxies -- jets of non-thermal radiation – two-lobed appearance due ejection at high energies
Cygnus A

Cygnus A (3C 405)

Radio Optical

HST closeup

VLA – 6 cm

VLBI 18 cm

VLBI 1.3 cm

VLBI 7 mm

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Cen A – radio emission

Giant elliptical
M87

M87 – jet from nucleus
Seyfert galaxies

Carl Seyfert 1943

Figure 13.20. Negative prints of various exposure lengths of the Seyfert galaxy NGC4151. (a) A short exposure shows only the bright nucleus. (b) A longer exposure yields the hint of spiral arms, while (c) a deep exposure burns out the nuclear regions and exhibits both the disk and arms of a spiral galaxy. (From W. W. Morgan, Ap. J., 153, 1968, 27; photographic materials from the Mt. Wilson and Palomar Observatories.)
Seyfert galaxies – very luminous central nucleus
strong infrared and radio sources

Quasars – Quasi-stellar Object (QSOs)
Central source so luminous appears star-like

3C 273
Some history

Twinkle, twinkle, quasi-star,
Biggest puzzle from afar.
How unlike the other ones,
Brighter than a trillion Suns.
Twinkle, twinkle, quasi-star,
How I wonder what you are!

- George Gamow
The central engine for active galaxies, radio galaxies, quasars -- supermassive black holes