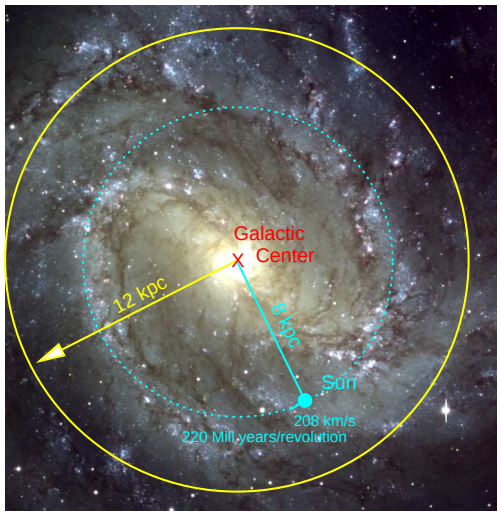
Galaxies: Classification

Milky Way, III

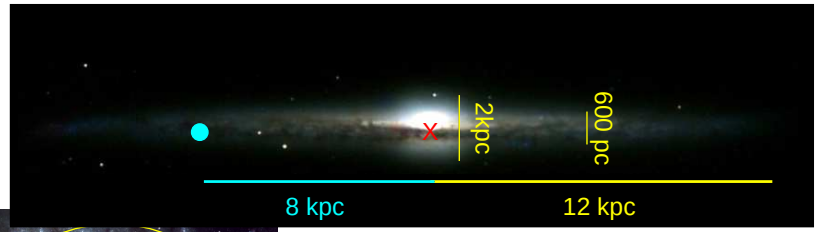


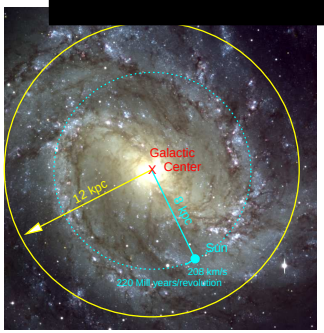
M83: ESO [VLT ANTU+FORS1]

Luminosity: $\sim 2 \times 10^{10}\, L_\odot$
Mass: $\sim 10^{11}\, M_\odot$ (radiating)
$\sim 10^{12}\, M_\odot$ (total)
Stellar density:
$\sim 0.3\, M_\odot\,\mathrm{pc}^{-3}$

$1\, M_\odot = 2 \times 10^{30}$ kg,
$1\, L_\odot = 4 \times 10^{26}$ W

Milky Way, IV





NGC 4565: W. McLaughlin

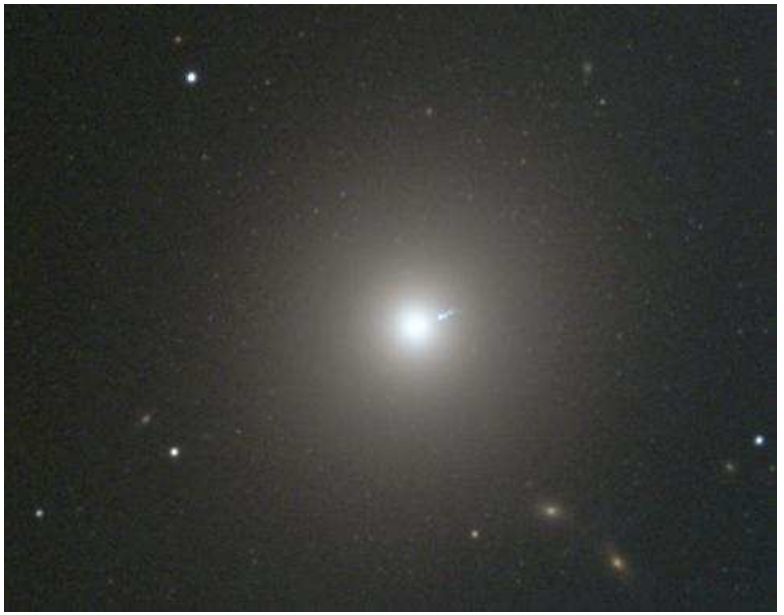
Luminosity: $\sim 2 \times 10^{10}\, L_\odot$
Mass: $\sim 10^{11}\, M_\odot$ (radiating)
$\sim 10^{12}\, M_\odot$ (total)
Stellar density:
$\sim 0.3\, M_\odot\,\mathrm{pc}^{-3}$

$1\, M_\odot = 2 \times 10^{30}$ kg,
$1\, L_\odot = 4 \times 10^{26}$ W

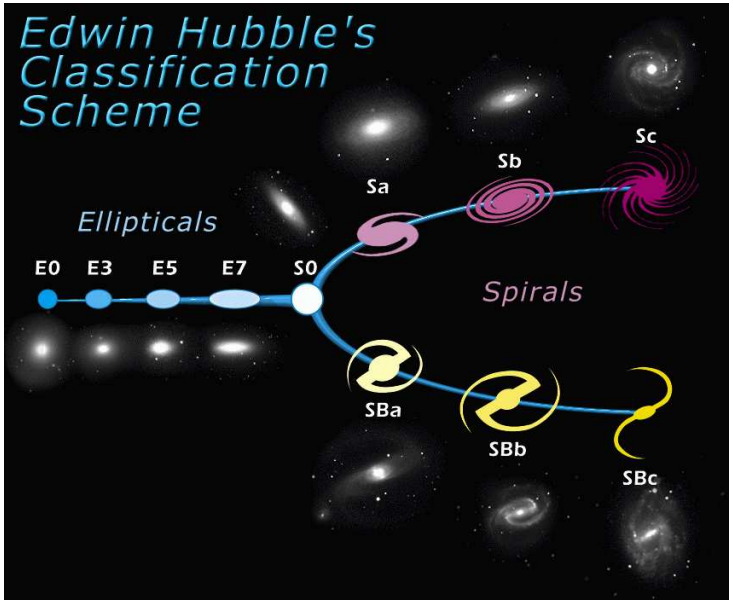
Andromeda galaxy (closest real neighbour galaxy, diam. 20kpc, distance: 675 kpc), NOAO/AURA/NSF

Virgo cluster, Burnell Schmidt telescope, NOAO/AURA/NSF

Deep looks in the universe: galaxies as building blocks

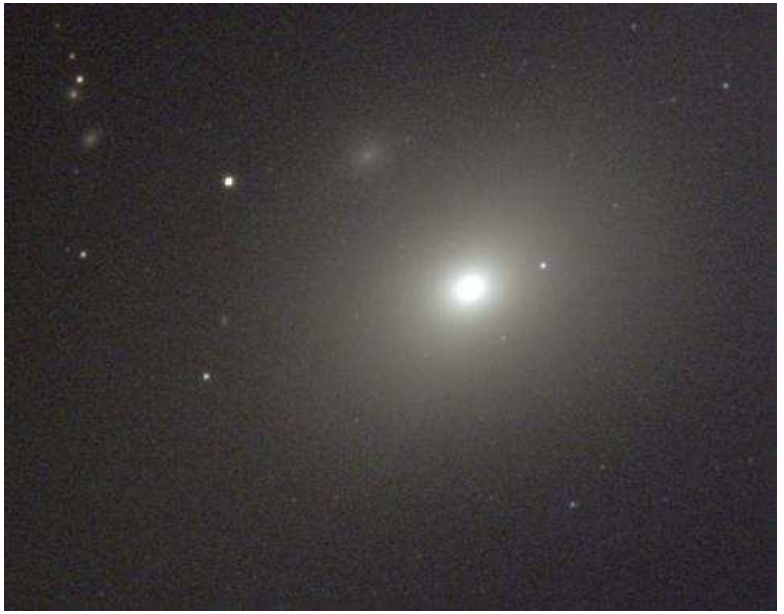


M87 (=Virgo A, note jet; E0), NOAO/AURA/NSF



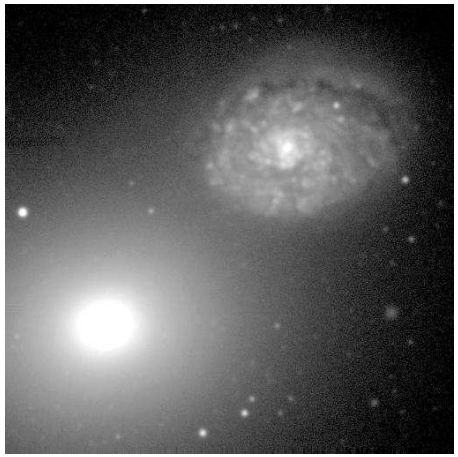
SDSS

Galaxy classification via the Hubble “tuning fork diagram”

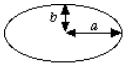


M86 (lenticular, S0), NOAO/AURA/NSF

Elliptical Galaxies



M60 (NGC 4649), E1, U. of Alabama



Elliptical galaxies: Classification as Ex where $x = 10(a-b)/a$ (integer part; between 0 and 7)

Ellipticals are low on dust and gas, reddish color (=old stars!), typically low luminosity and low mass ($10^6\ M_\odot$)

Monsters: Also elliptical, from mergers in galaxy clusters (e.g., M87 in Virgo), M up to $10^{12}\ M_\odot$, designated cD.

M90 (Sb), NOAO/AURA/NSF

M104 (Sa; “Sombrero galaxy), HST/NASA

NGC 4565 (Sb, seen edge on), McLaughlin

M51 (Sc), NOAO/AURA/NSF, T. Rector

Spiral Galaxies

M51 (NGC 5194 and 5195), Sc and Irr, Kitt Peak 0.9 m

Spiral Galaxies: Elliptical nucleus plus spiral arms, designated Sa, Sb, Sc depending on opening angle of spiral (Sa: $\sim 10^\circ$, Sc: $\sim 20^\circ$) and dominance of nucleus.

Bluer than ellipticals.

Mass content $\sim 3 \times 10^{11}\, M_\odot$, with $M/L \sim 20$,

Gas content increases from Sa to Sc from 1% to 8%.

Spiral arms probably due to density wave.

M51 (Sc; centre), HST/NASA

M83 (SABc, ESO)

NGC 1365 (SBb, VLT/FORS/ANTU): note old “reddish” bar, young spiral arms

Large Magellanic Cloud (LMC; Irr I), Loke Kun Tan

Barred Galaxies

M95 (NGC 3351), SBb, INT

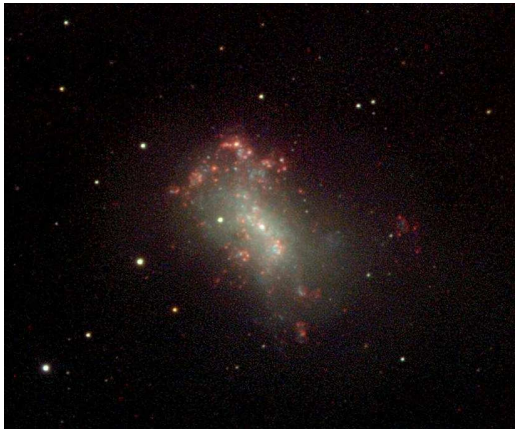
Barred Galaxies: Classification as SBa, SBb, SBc similar to Sx galaxies, but additional presence of a bar (cause of bar production and stability are still debated).

Similar masses and gas content as in normal spirals.

Milky Way is a barred spiral.

Large Magellanic Cloud (LMC; Irr I), AURA/NOAO/NSF

Irregular Galaxies: Irr I



NGC 4449, Univ. Bonn

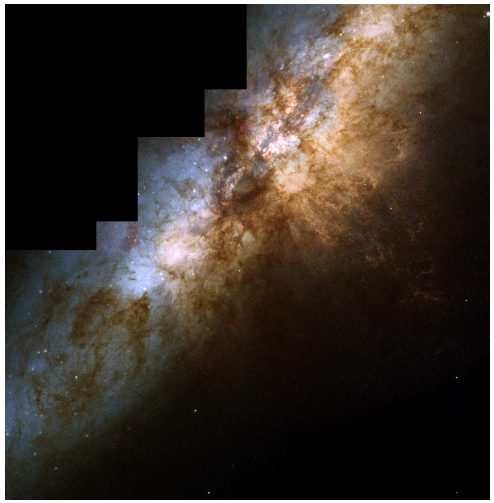
Irr I: no symmetry or spiral arms, bright knots of O- and B-type stars, very blue ($B-V \sim 0.5$), high dust content ($\sim$ 16%), $M/L \sim 3$, masses vary appreciably from 10^6 to $10^{10}\,M_\odot$.

Examples: SMC, LMC

$\Longrightarrow$ "Magellanic type irregulars".

NGC 6946, T. Rector/AURA/Gemini

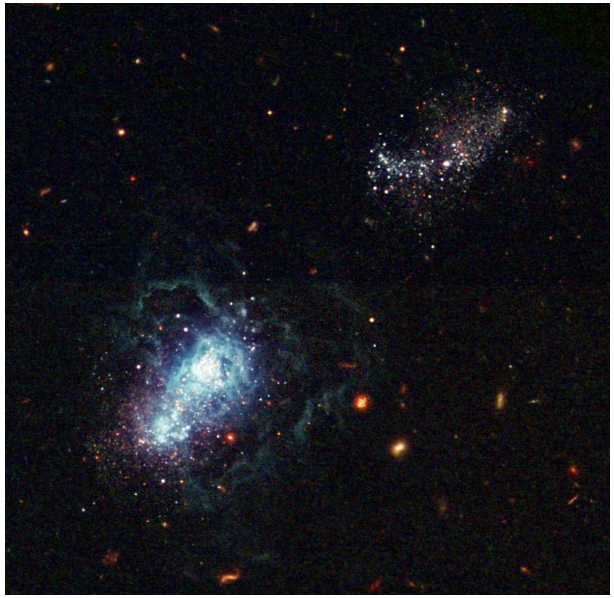
Irregular Galaxies: Irr II



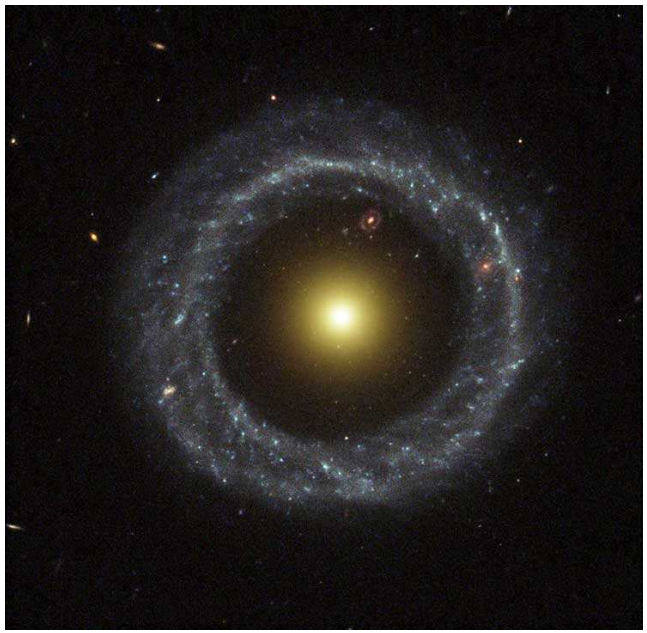
M82, HST-WFPC

Irr II: unsymmetrical and "abnormal"

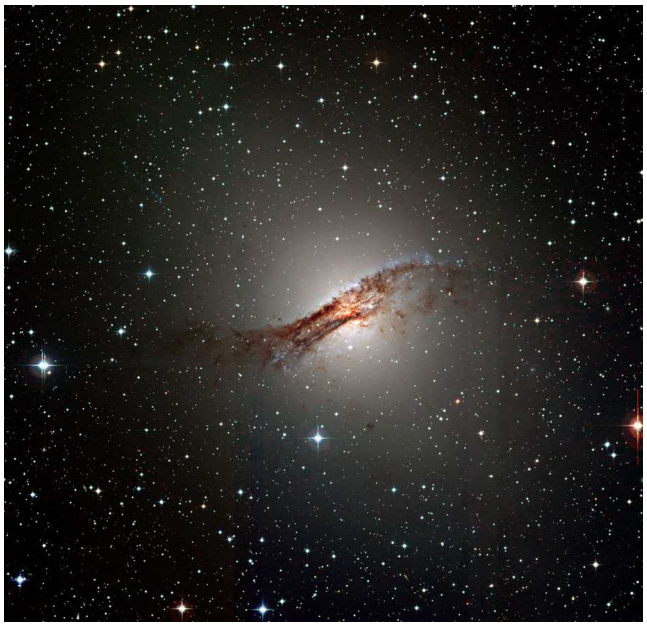
$\Longrightarrow$ All objects that do not fit in the rest of the classification: starburst galaxies, interacting galaxies, Active Galactic Nuclei,. . .



I Zwicky 18, Y. Izotov/T. Thuan/HST



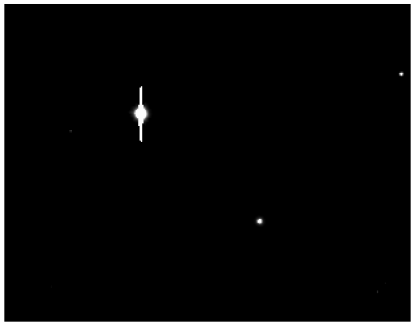
Hoag's Object, HST



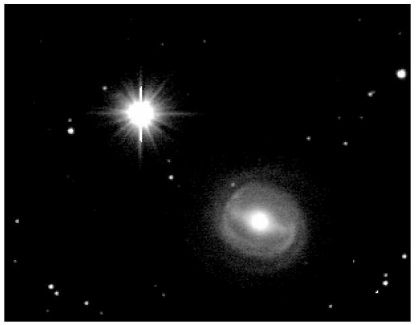
Cen A, ESO/WFI

NGC 1300, HST

AGN



NGC 3783: *linear* intensity scale

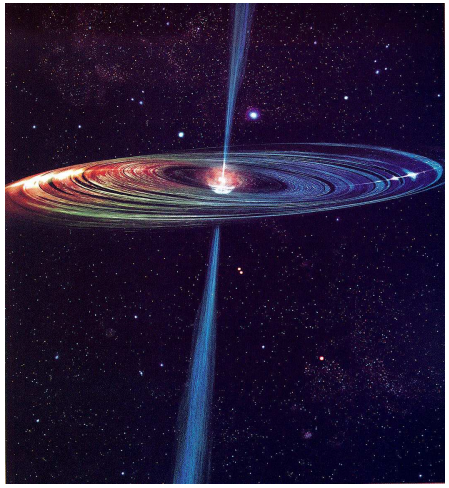


logarithmic intensity scale

Active Galactic Nuclei (AGN): supermassive black holes ($M \sim 10^{6\ldots8}\,M_\odot$), accreting $1\ldots2\,M_\odot$/year

$\Longrightarrow$ Luminosity $\sim 10^{10}\,L_\odot$ (comparable to galaxy luminosity)

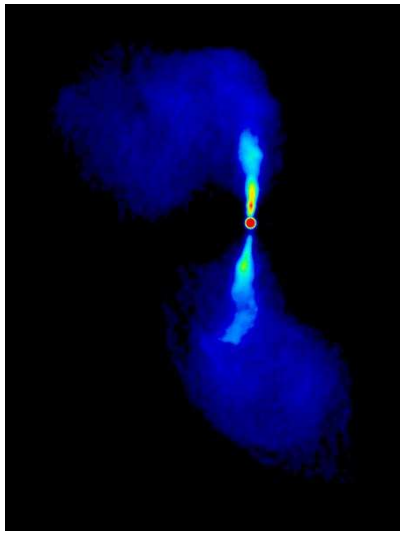
AGN



Structure of active galactic nuclei similar to galactic black holes (although somewhat scaled up...)

- supermassive black hole ($10^7\,M_\odot$)
- accretion disk ($\dot{M} \sim 1 \ldots 2\,M_\odot\,\mathrm{yr}^{-1}$)
- large luminosity ($L \sim 10^{10}\,L_\odot$)
- Schwarzschild radius now ~ 1 AU

AGN



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- accretion disk ($\dot{M} \sim 1 \ldots 2\,M_\odot\,\mathrm{yr}^{-1}$)
- large luminosity ($L \sim 10^{10}\,L_\odot$)
- Schwarzschild radius now ~ 1 AU
- often relativistic jets, where material is accelerated to the speed of light

AGN *with* jets: quasars, blazars...
AGN *without* jets: Seyfert galaxies