Bar Parameters of Seyfert and Inactive Galaxies

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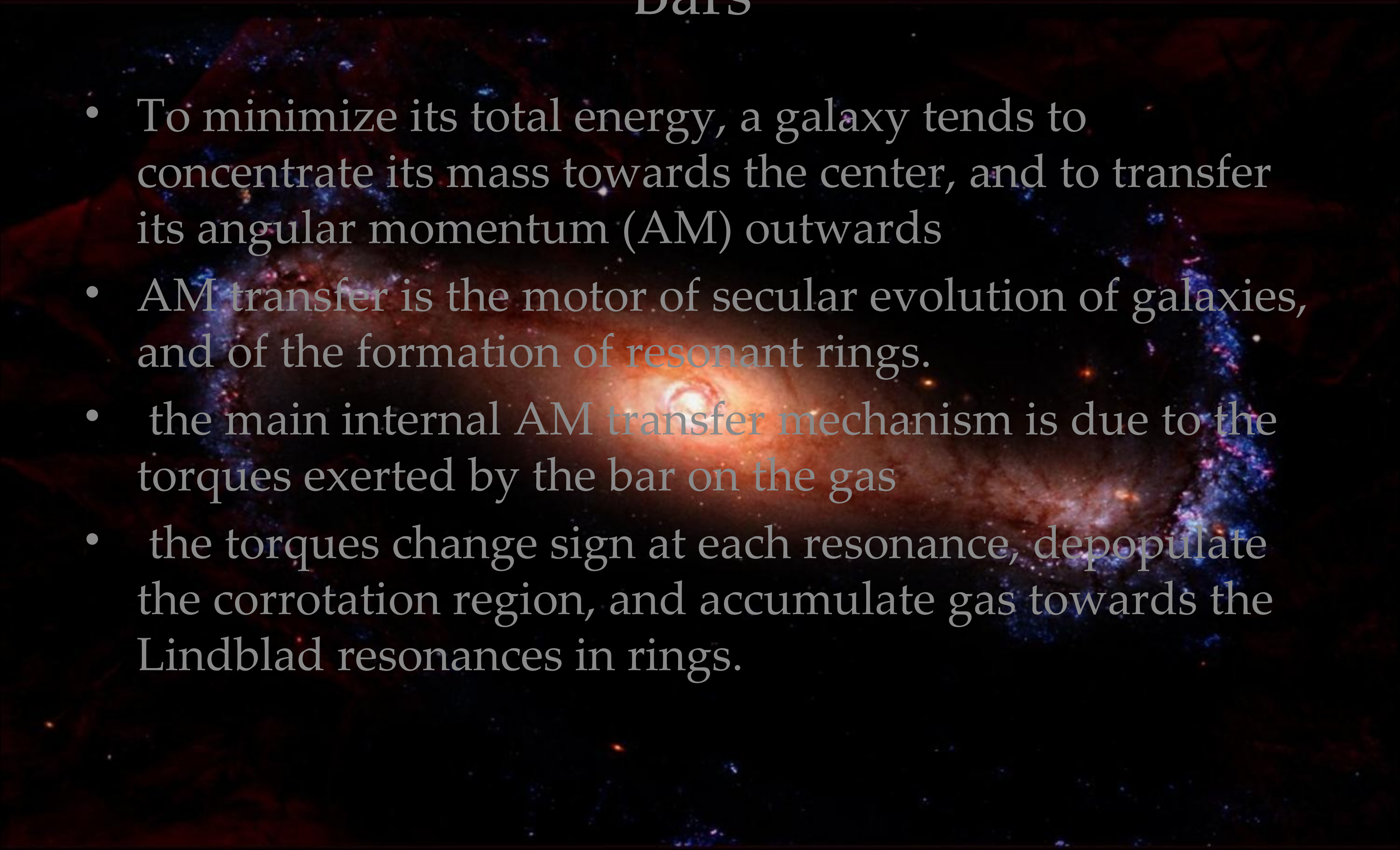
Bars



- To minimize its total energy, a galaxy tends to concentrate its mass towards the center, and to transfer its angular momentum (AM) outwards
- AM transfer is the motor of secular evolution of galaxies, and of the formation of resonant rings.
- the main internal AM transfer mechanism is due to the torques exerted by the bar on the gas
- the torques change sign at each resonance, depopulate the corrotation region, and accumulate gas towards the Lindblad resonances in rings.

Orbits and resonances in barred potential

bisymmetric potential, gravity torques

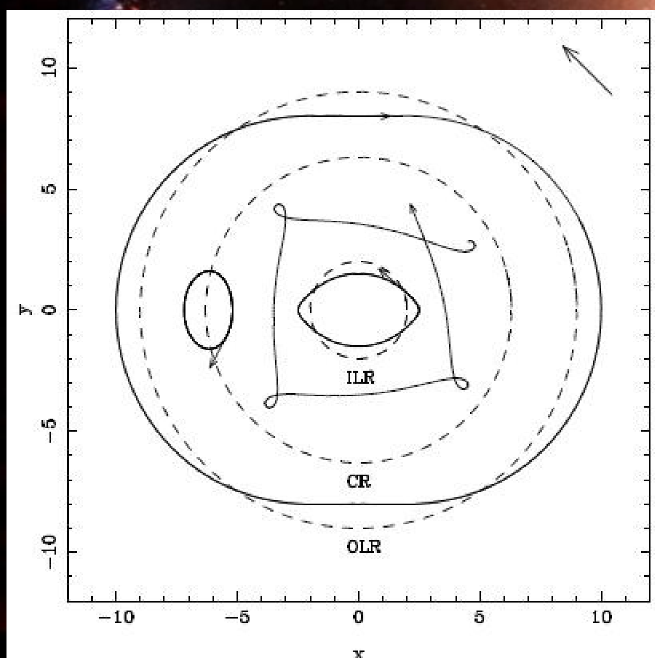
$\Omega = \Omega_b$ - corrotation resonance

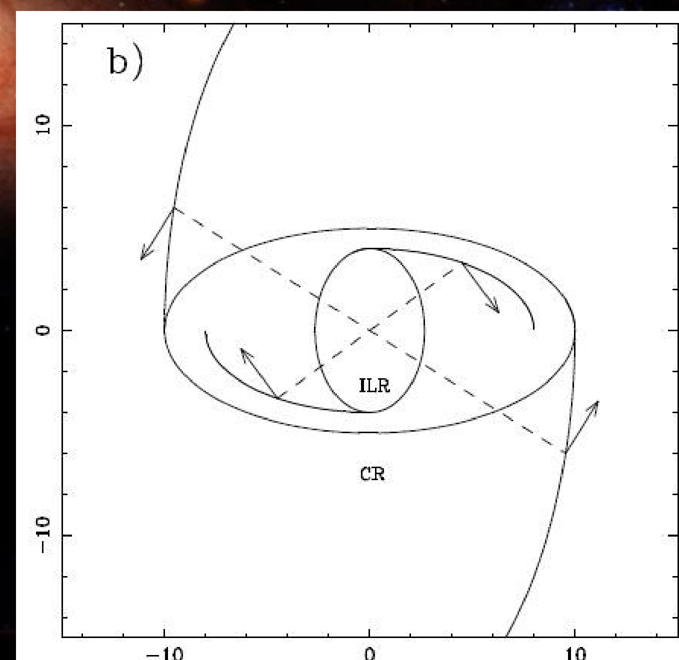
$\Omega - \Omega_b = +k/m$ - inner Lindblad resonance

$\Omega - \Omega_b = -k/m$ - outer Lindblad resonance

$$\tau(x, y) = xF_y - yF_x,$$

$$F_{x,y}(x, y) = -\nabla_{x,y}\Phi(x, y)$$





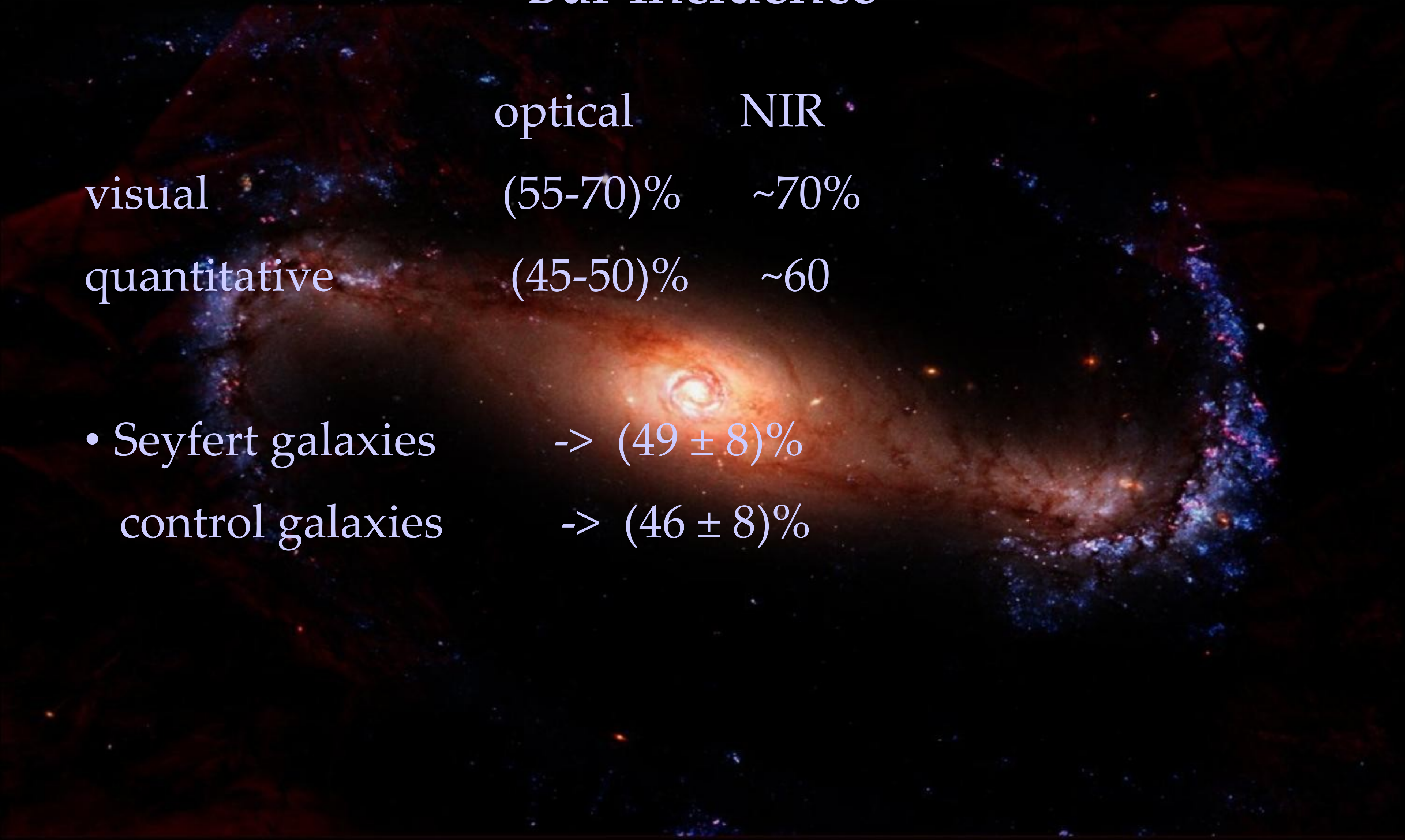
Matched Samples

A sample of 35 Seyfert galaxies and a control sample of inactive galaxies matched on:

- *T*; * $T = 0/0$
- V_r; * $V_r = 8089/7934$ km s^{-1}
- M^B_{abs}; * $M^B_{abs} = -20^m88/-21^m03$
- ϵ. * $\epsilon = 0.19/0.20$

- Compiled in the course of a project on AGN study (Slavcheva-Mihova & Mihov 2011, 526, A43)

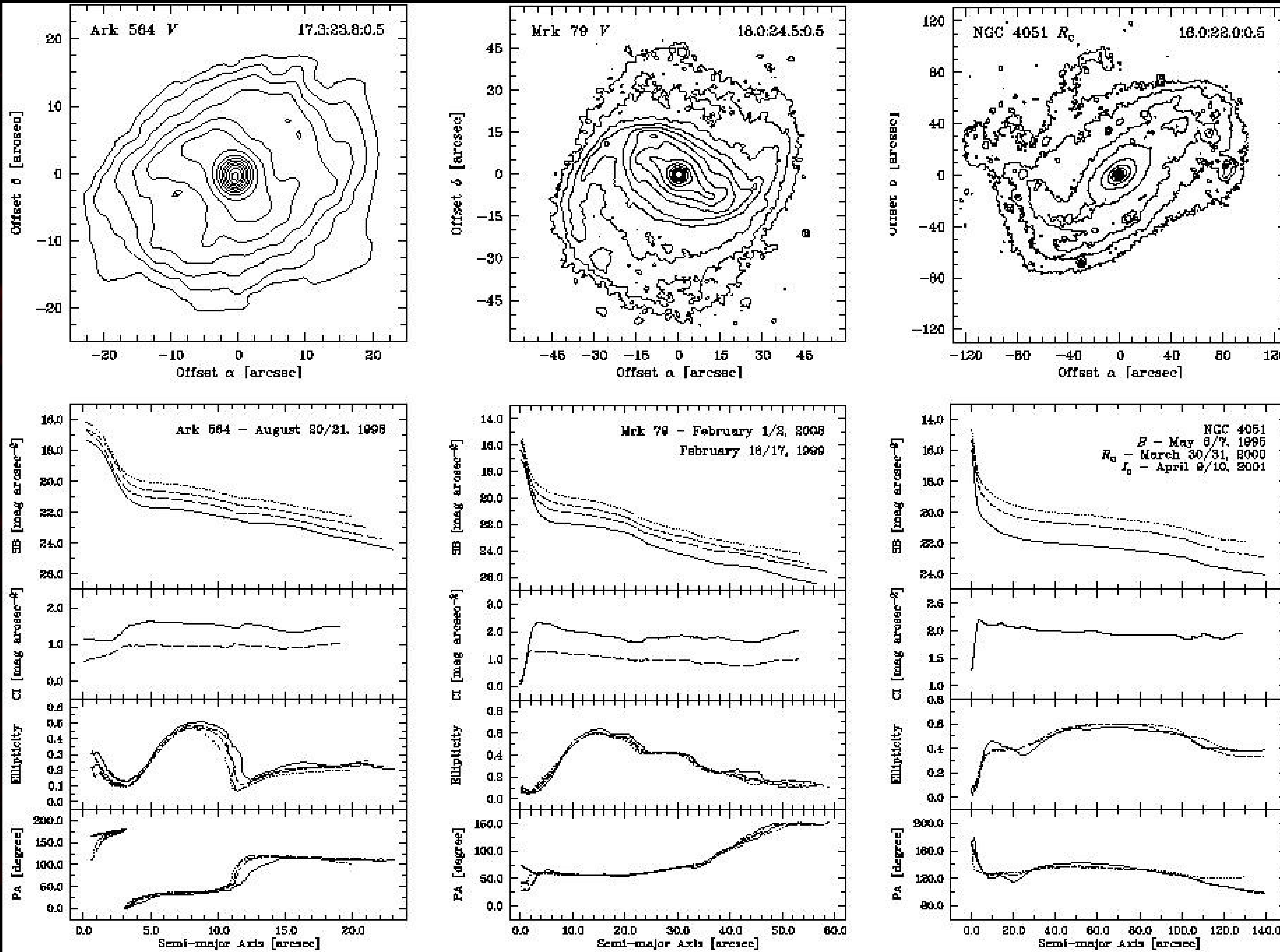
Bar Incidence



	optical	NIR
visual	(55-70)%	~70%
quantitative	(45-50)%	~60

- Seyfert galaxies -> (49 ± 8)%

  control galaxies -> (46 ± 8)%



Ark 564 V
17.3:23.8:0.5
Offset δ [arcsec]
Offset α [arcsec]
Mrk 79 V
16.0:24.5:0.5
NGC 4051 R_c
16.0:22.0:0.5
Ark 564 – August 20/21, 1996
Mrk 79 – February 1/2, 2003
February 16/17, 1999
NGC 4051
B – May 6/7, 1995
R_c – March 30/31, 2000
I_c – April 9/10, 2001
SB [mag arcsec^{-2}]
CI [mag arcsec^{-2}]
Ellipticity
PA [degree]
Semi-major Axis [arcsec]

Bar Characterization

- Bar criteria:
  - $\epsilon^{(\max)}_{\mathrm{bar}} > 0.16$
  - $\Delta\,\epsilon_{\mathrm{bar}} > 0.06$
  - $\Delta\,\mathrm{PA} < 20^{\circ}$

- Bar signatures on the profiles can be masked by spiral arm stubs (NGC 6814, Mrk 771, NGC 7469) or other features at the bar edges (Mrk 771, Mrk 279)

Bar Length

Bar length estimation methods:

- visual inspection;
- analysis of the SB profile over bar major axis;
- ellipse fitting;
- Fourier analysis

a_{max} - most objective and reproducible

- not related to any of the bar dynamical characteristics

Bar Length Estimation of Ours

- $\mathcal{D}$**bar - MA**, where the ϵ_{bar} decreases with 15% from ϵ_{max} after Martinez-Valpuesta, Shlosman & Heller (2006)

$\mathcal{D}_{\mathbf{bar}}$**-** the size of the maximal stable x_1 orbit (Fathi et al. 2009).

- The post-maximum ϵ_{bar} slope, steeper than the pre-

maximum one, is often influenced by spiral arms or rings.

- To reduce this influence, we took the minimum of

the MAs, corresponding to the 15% ϵ_{bar} decrease, both before and after the ϵ_{max}.

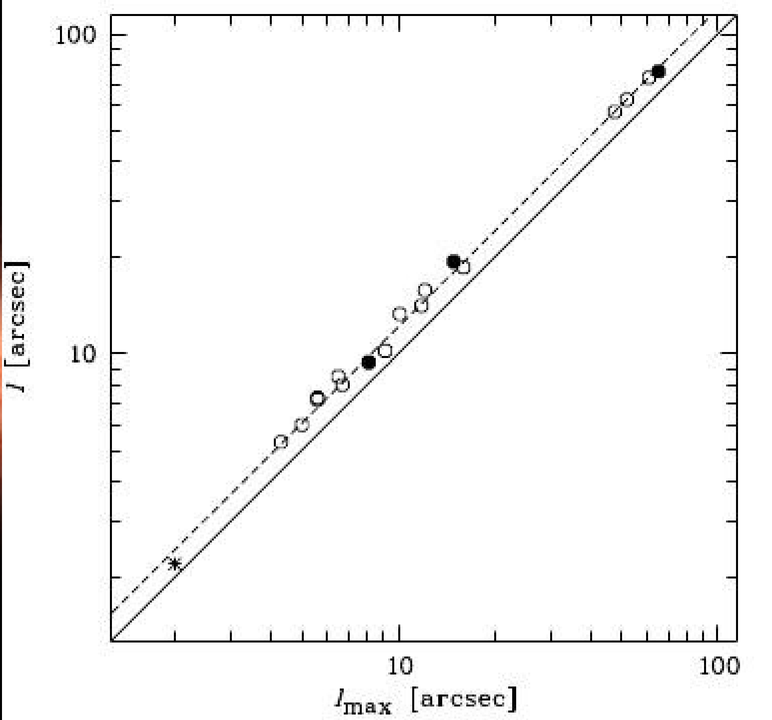
Bar Length Estimation of Ours

Deprojection

$$\ell^{(i)} = \ell\sqrt{\cos^2\Theta + \sec^2 i\,\sin^2\Theta}$$

Pearson's correlation coefficient r

r = 0.999



- Medianr $\mathcal{D}_{bar}/\mathcal{D}_{max}$ ~ 1.22

Bar Strength

- Bar strength: $$Q_t(r) = \left.\partial\Phi/\partial\varphi\right)_{\max} \Big/ r\,\frac{\partial\Phi_0}{\partial r}$$

the maximal tangential in terms of the mean radial force

- $\epsilon_{bar} \sim Q$ (Athanassoula 1992; Block et al. 2004)

- strong bars: $\epsilon^{(i)}_{bar} > 0.45$ (Laine et al. 2002)

  $\epsilon^{(i)}_{bar} > 0.40$ (Martinet & Friedli 1997)

- $\epsilon^{(i)}_{bar} < 0.15$: ovals/lenses

  - Mrk 595, Mrk 279, NGC 7469

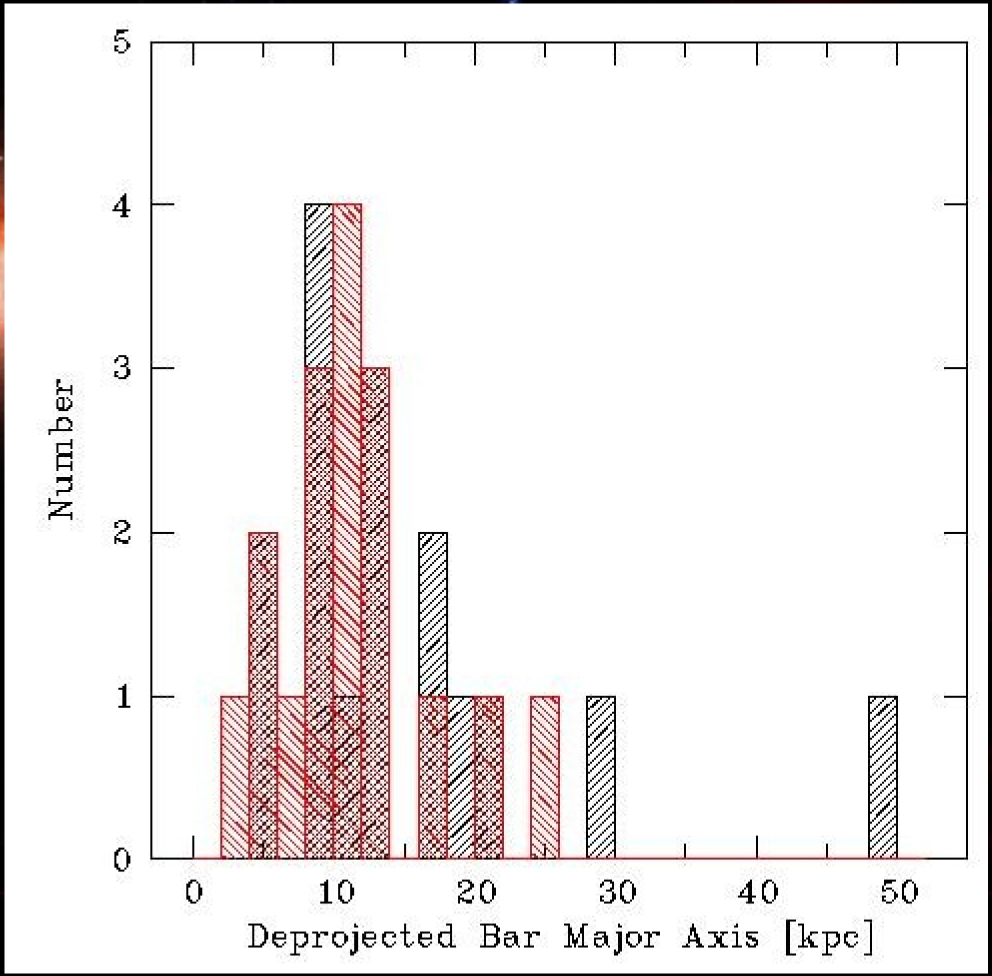
Deprojected Bar Major Axis

the difference is insignificant at 95% confidence level

Median $\mathcal{D}_{bar}$ [kpc]

Seyfert -> 11.10 (5.33)

Inactive -> 12.50 (10.70)



Deprojected Relative Bar Major Axis

the difference is insignificant at 95% confidence level

Median $\mathcal{D}_{bar}$ $/D_{25}^{B,0}$

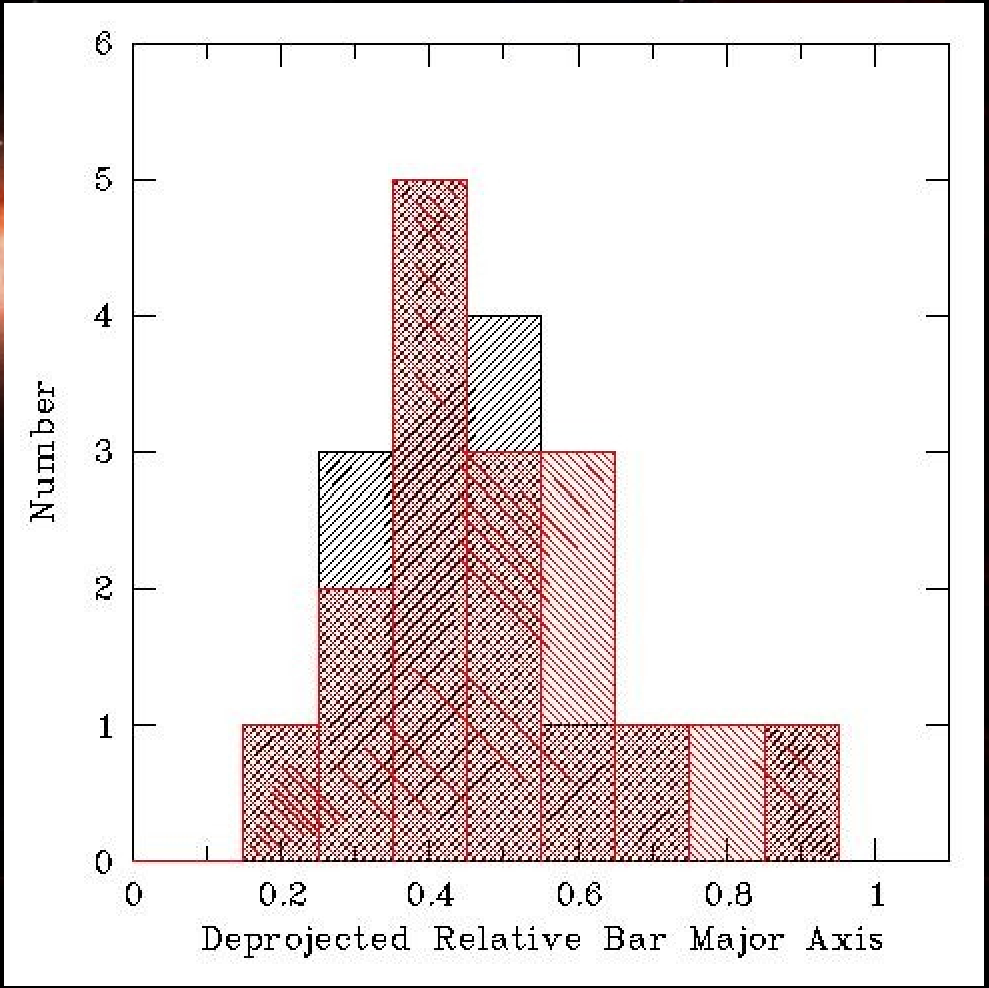
Seyfert -> 0.45 (0.19)

Inactive -> 0.43 (0.17)

- $\mathcal{D}_{bar}$

cosmological dimming-corrected

K- & E-corrected



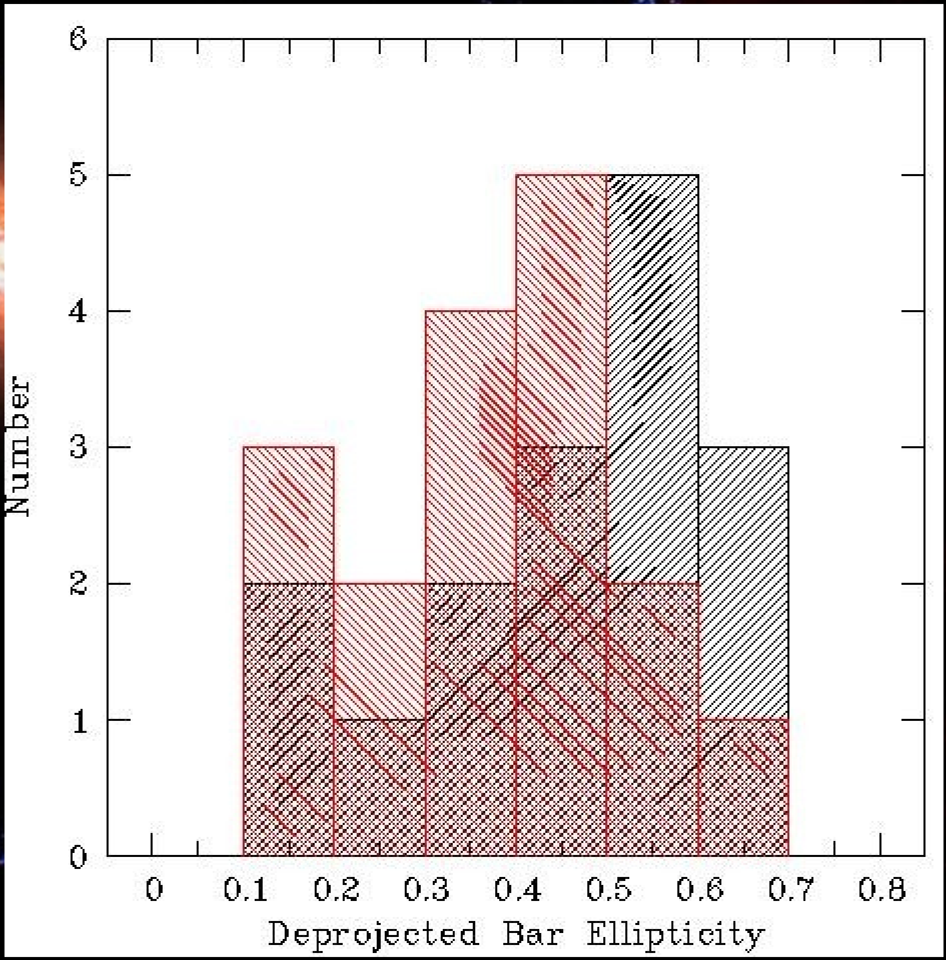
Deprojected Bar Ellipticity

The Seyfert bars are weaker than the inactive ones at 95% confidence level

Median $\epsilon^{(i)}_{bar}$

Seyfert -> 0.39 (0.12)

Inactive -> 0.49 (0.14)



it cannot be explained

with the Hubble type *T*

Discussion on Bar Strength

• bars are less fragile than previously thought, and the mass of the central concentration required to dissolve the bar x_1 morbits must be very high (e.g., Shen & Sellwood 2004)

• the main destruction mechanism could be the transfer of AM from the gas inflow to the bar (e.g., Bournaud et al. 2005)

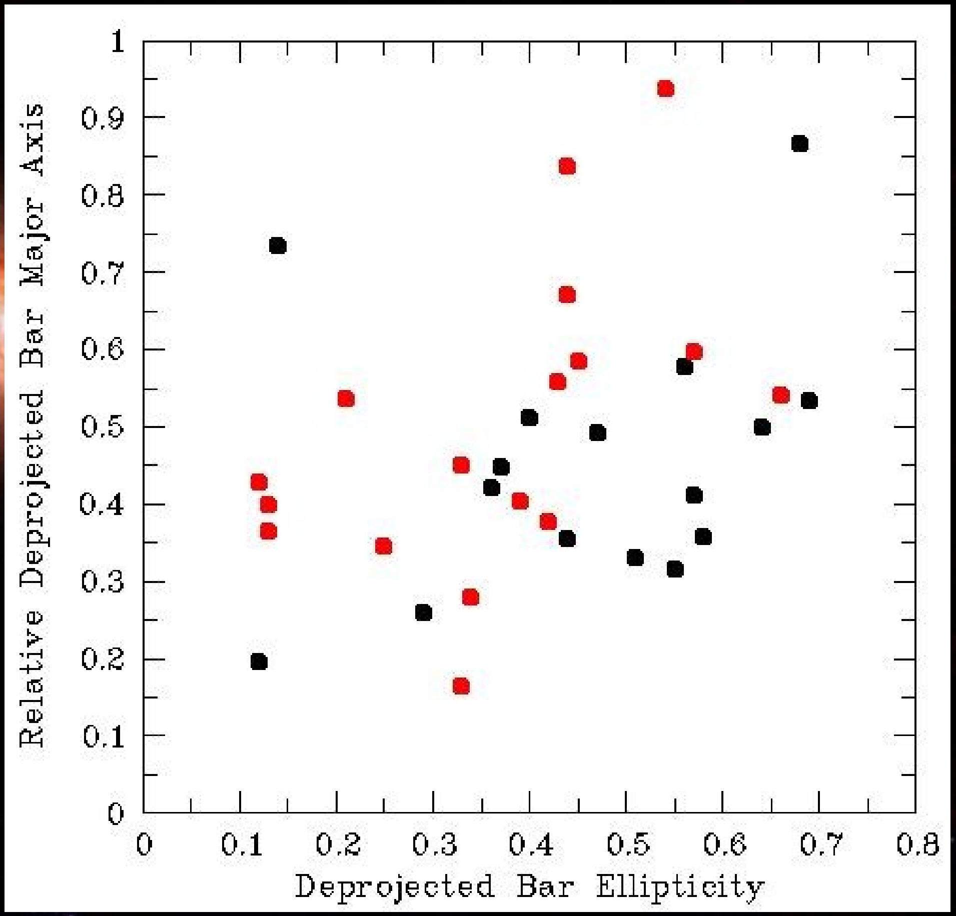
• the weaker Seyfert bars may be related to the generally larger cold gas amounts reported in their disks (e.g., Hunt et al. 1999, see also Ho et al. 2008) in the context of AM transfer.

Relative Deprojected Bar Major Axis vs. Deprojected Bar Ellipticity

$\mathcal{D}_{bar}/D_{25}^{B,0} \sim \epsilon_{bar}$

Seyfert r = 0.52

Inactive r = 0.29

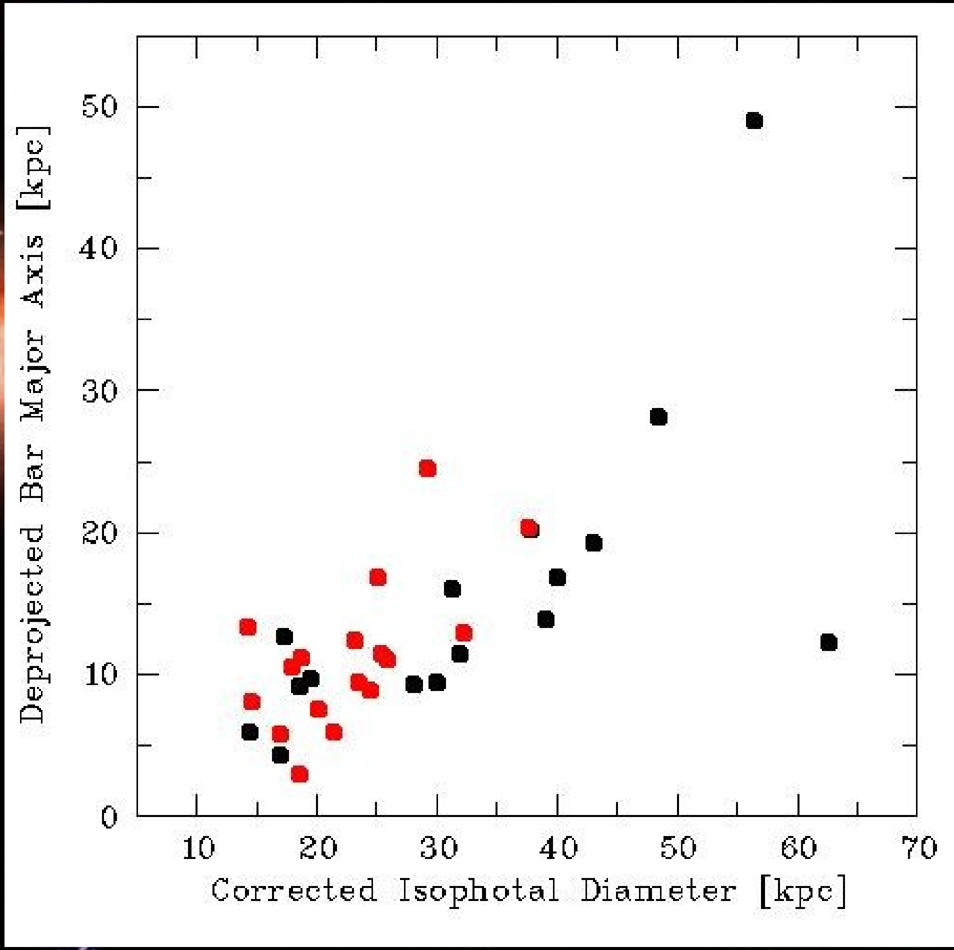


Deprojected Bar Major Axis vs. Corrected Isophotal Galaxy Diameter

$\mathcal{D}_{bar} \sim D_{25}^{B,0}$

Seyfert r = 0.64

Inactive r = 0.67

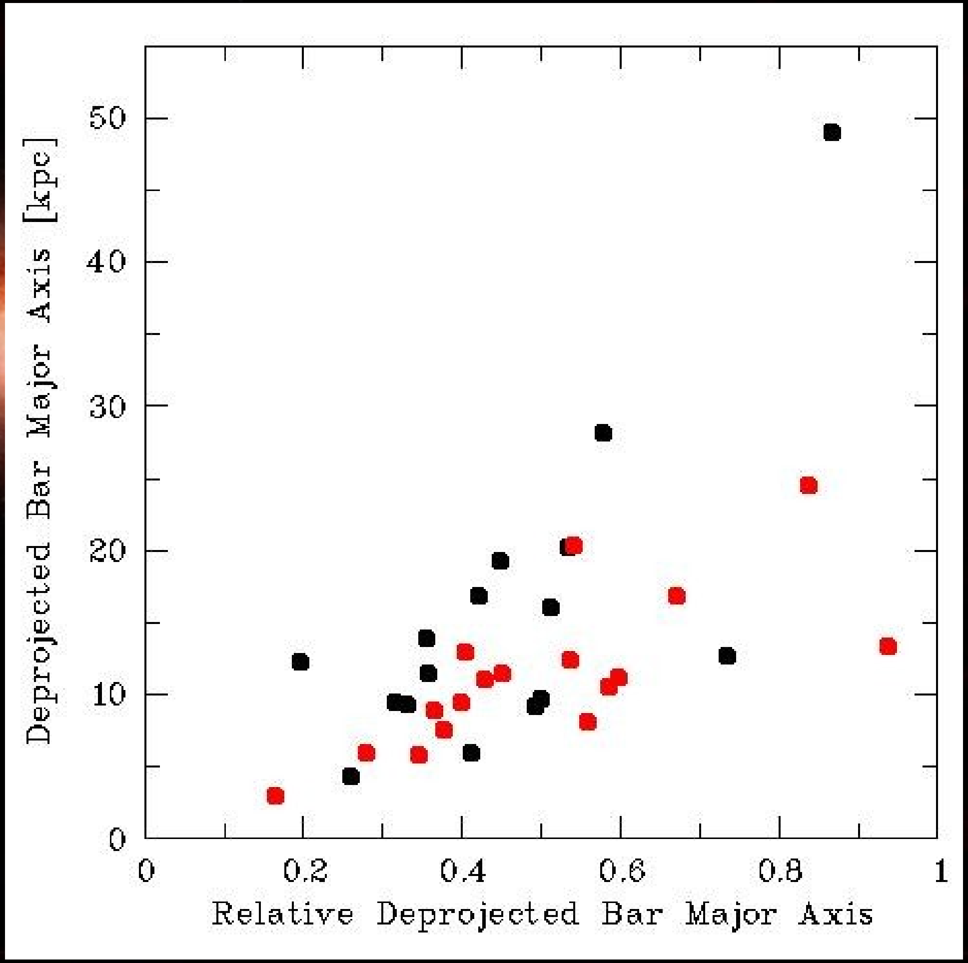


Deprojected Bar Major Axis vs. Relative Deprojected Bar Major Axis

$\mathcal{D}_{bar} \sim \mathcal{D}_{bar}/D_{25}^{B,0}$

Seyfert r = 0.73

Inactive r = 0.73



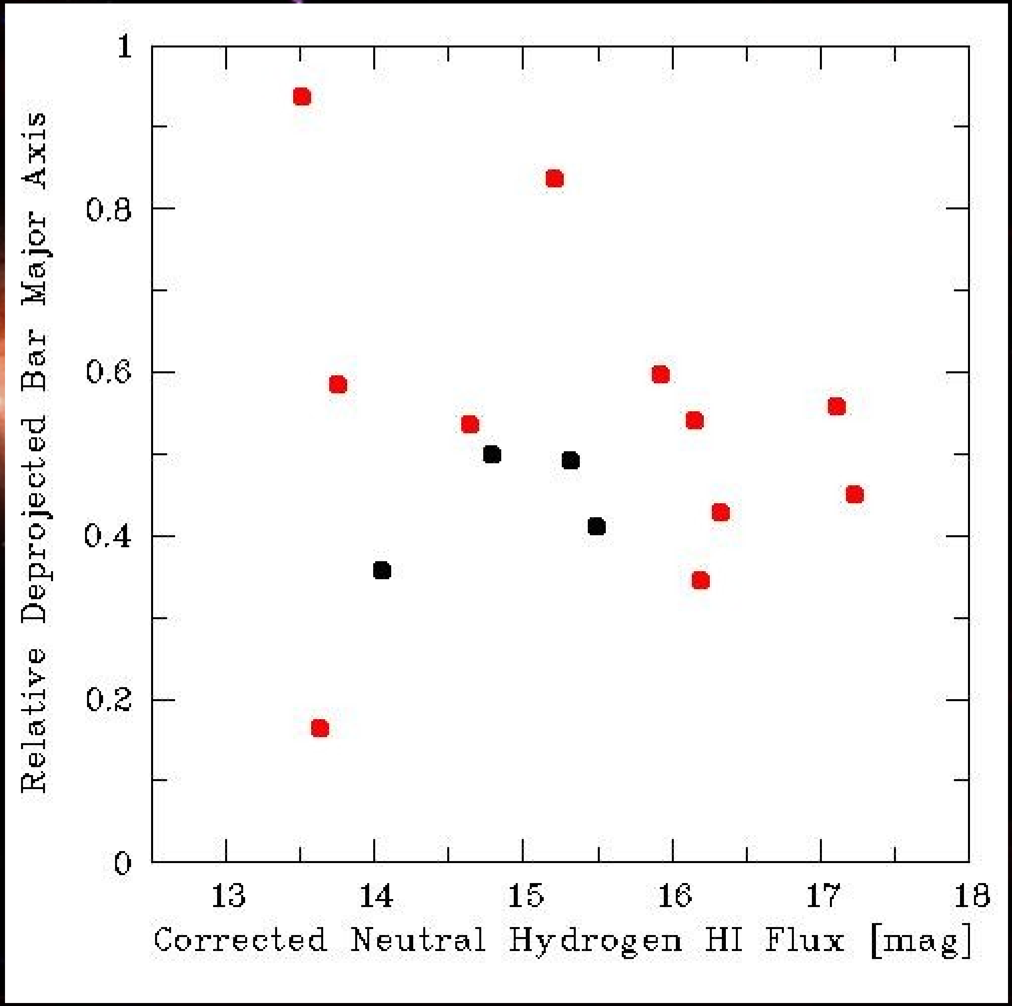
Deprojected Bar Major Axis vs. Neutral Hydrogen Flux

$\mathcal{D}_{bar}/D_{25}^{B,0} \sim M_{HI,C}$

Seyfert r = 0.20

lower left point removed

Seyfert r = 0.63

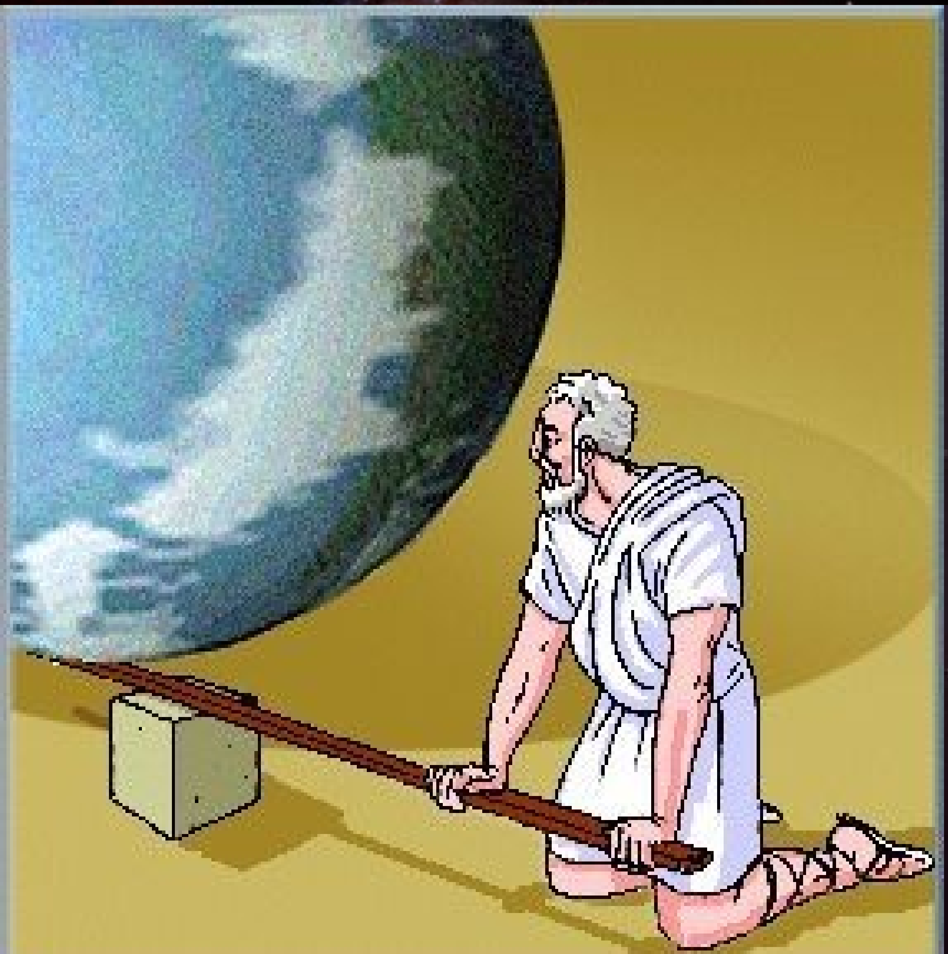


Future Perspectives

- data from homogeneous data bases with a better coverage
- larger samples needed to confirm/reject the weak tendencies found

- "Give me a lever long enough, and a fulcrum strong enough, and I will move the Earth."
  -Archimedes

- "Give me a bar long and strong enough, and I will reduce the bulk of gas AM of any galaxy."




Thank you for your attention!