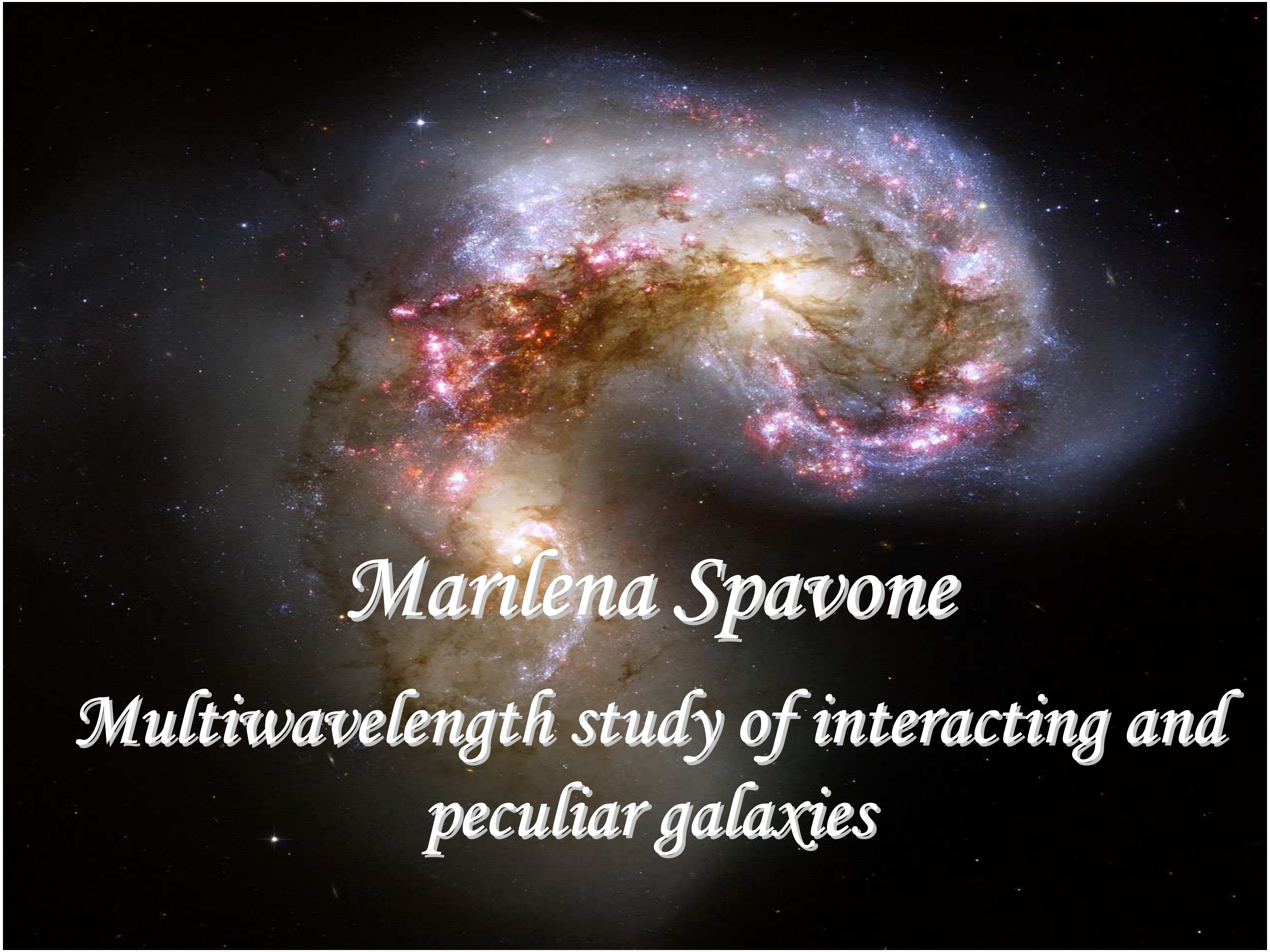
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Multiwavelength study of interacting and peculiar galaxies

The Toomre Sequence

Galaxies are not 'ISLAND UNIVERSES' they interact with their neighbors!

About 6% of galaxies are obviously PECULIAR they do not fit the standard galaxy types. They are TIDALLY DISTORTED

In 1972 Alar and Juri Toomre created computer simulations of galaxy interactions that were able to reproduce these peculiar structures

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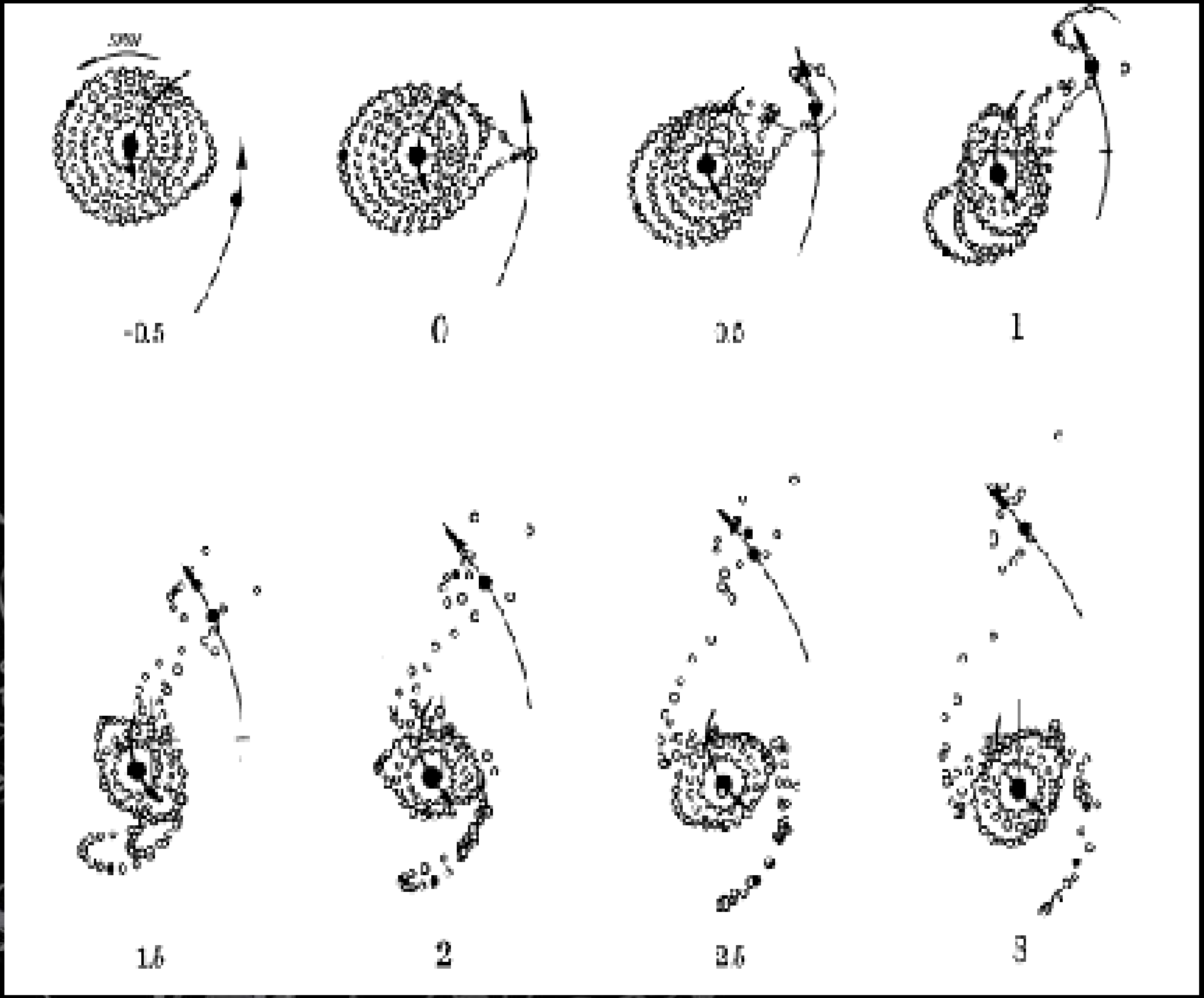
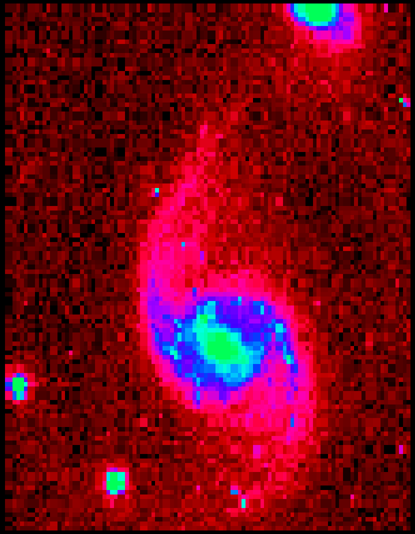
Toomre & Toomre simulations





ARP 82

A simulation by the Toomres of a low mass companion passing close to a disk galaxy

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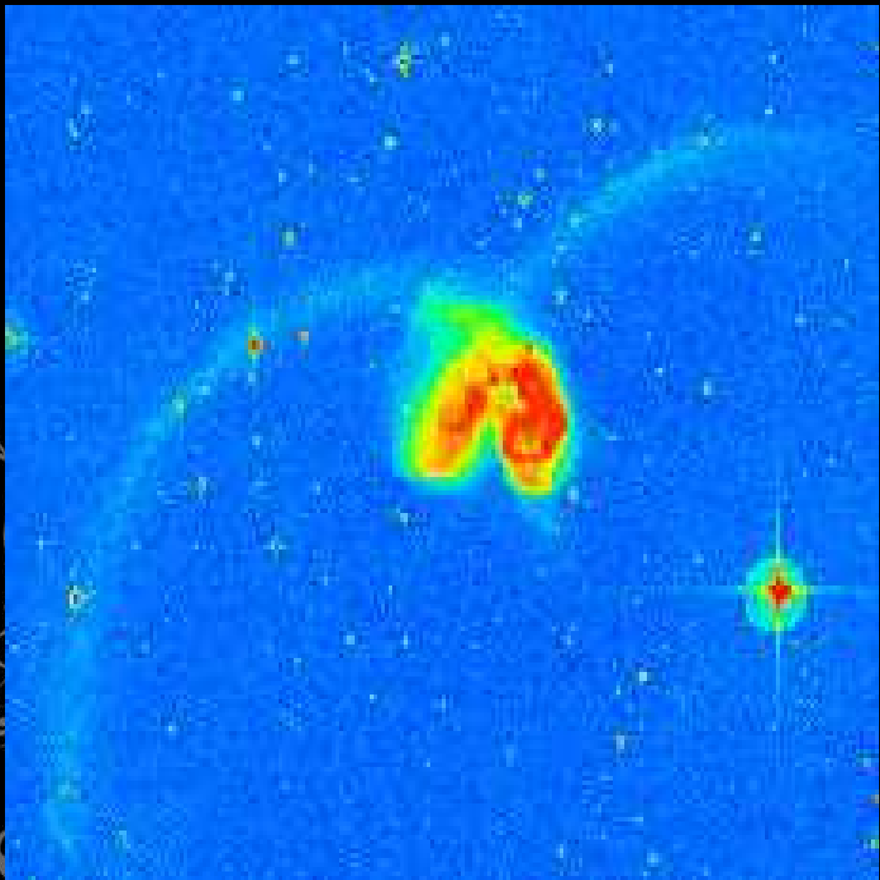
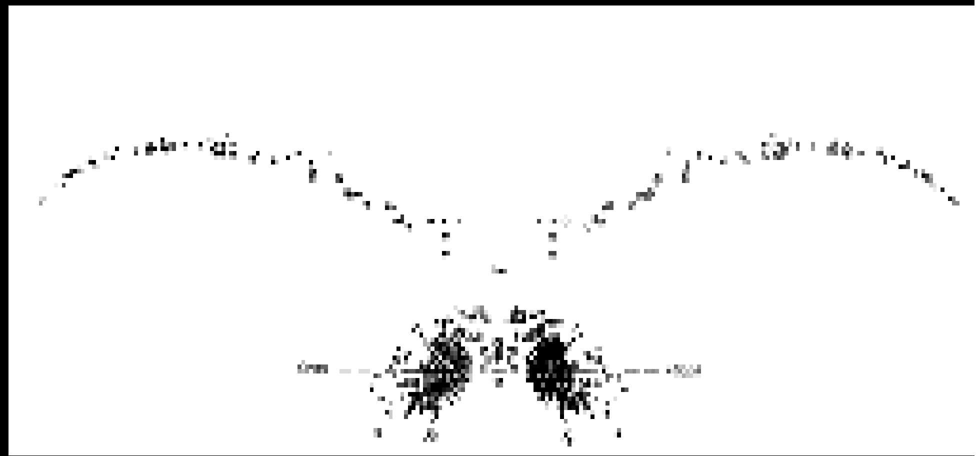
Toomre & Toomre simulations



Optical image of the Antennae galaxies



Computer model of the Antennae galaxies

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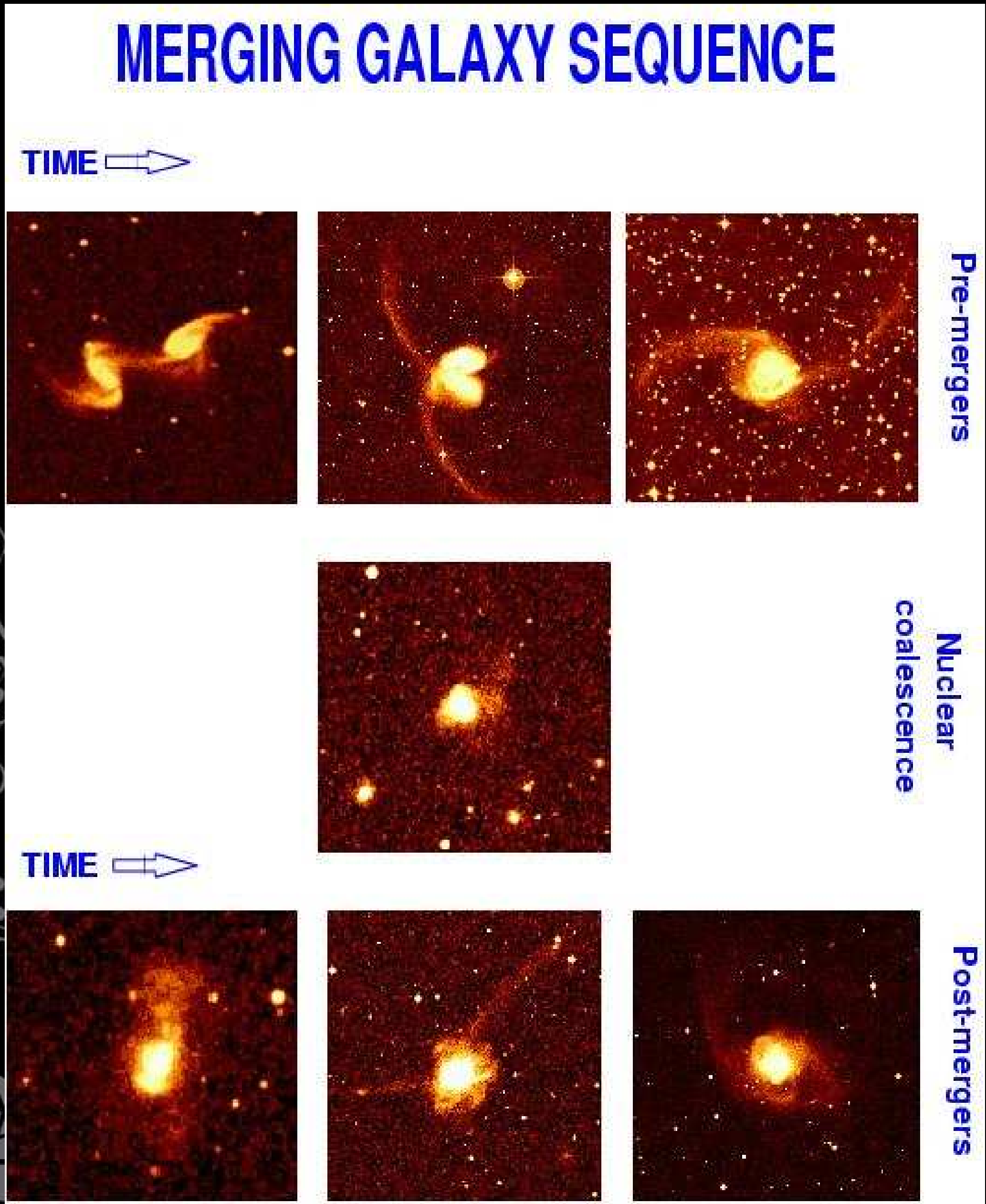
The Toomre Sequence



In 1977, by comparing photographs of galaxies with the simulations, Toomre defined a sequence of 11 objects with tidal tails, ordered on the basis of the degree of coalescence of the nuclei

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Comparison with dense environment: CGs

Stephan Quintet

✓High galaxies density (~10^4-10^6 gal/Mpc3) similar to that observed in the cores of some rich clusters

✓Low velocity dispersion (~150-250 km/s) less than one fifth of that observed in some cores of rich clusters

✓Dynamical friction becomes particularly effective → strong galactic interactions and merging

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Comparison with simulations

Formation and evolution of galaxies

Assembly of matter through accretion & merger

Conversion of matter into stars

Cold Dark Matter scenario

Observations ⟷ Simulations

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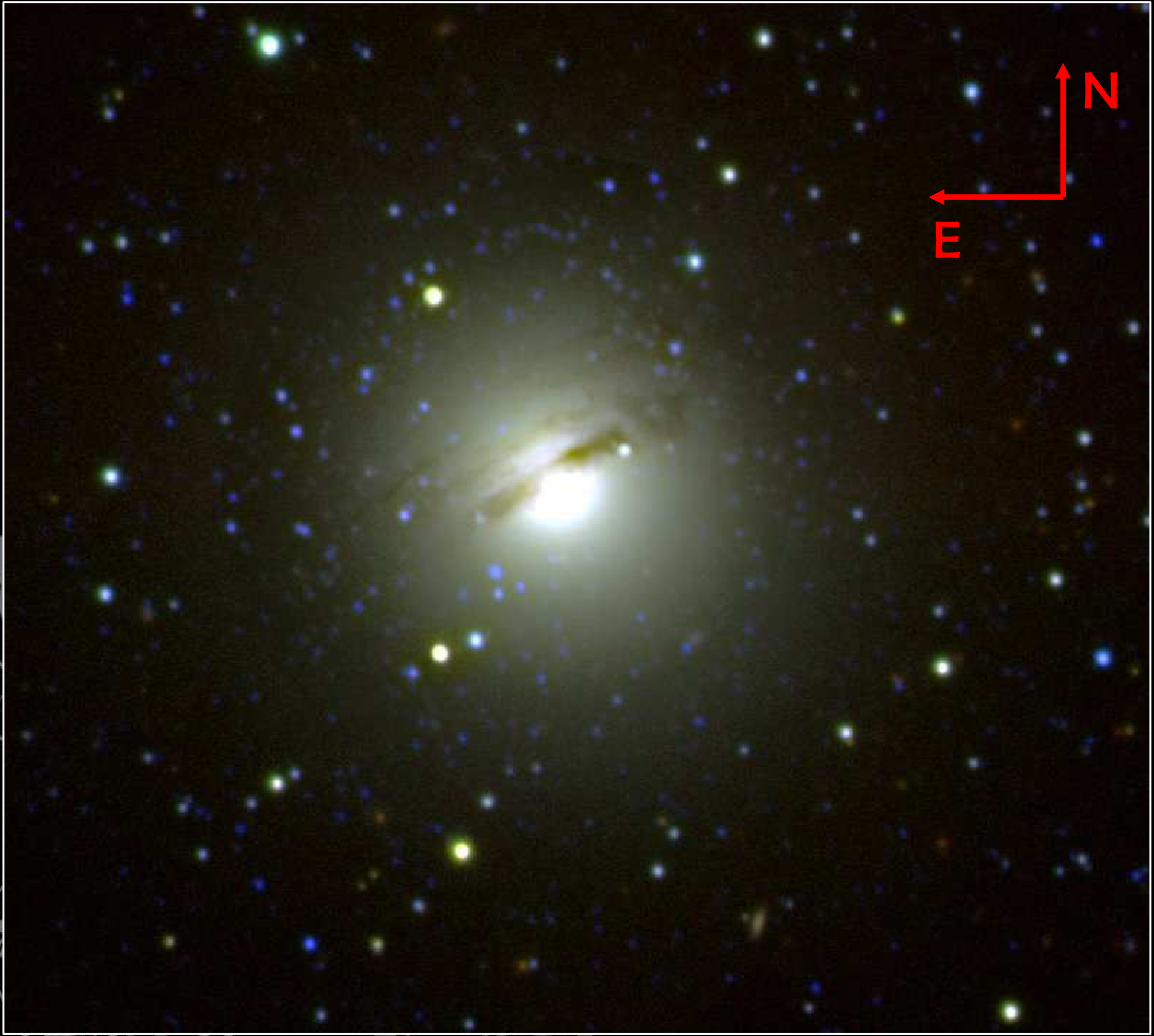
The minor axis dust lane galaxy NGC1947



z	0.004
D (Mpc)	14.67
Type	S0-pec
Vel (km/s)	1100
M_B	-20.21
$M_{HI}(M_\odot)$	3.4×10^8
$M_{dust}(M_\odot)$	15.3×10^5

"Spavone M., Iodice E., Calvi R., Bettoni D., Galletta G., Longo G., Mazzei P. and Minervini G., MNRAS"

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Merging or Tidal accretion?

Merging

No signs of significant interaction (tails, shells etc.)

→ the event would have occurred very long ago (10 Gyrs)

Inconsistent with the age of the last burst of star formation (1Gyr) and with the warping of the gas, that has not yet reached the equilibrium.

Tidal accretion

Bournaud et al. Simulations lead to the formation of polar structures through tidal accretion;

In the field around NGC1947 we found an early type spiral with HI distribution in the orbital configuration needed to form a polar structure through accretion

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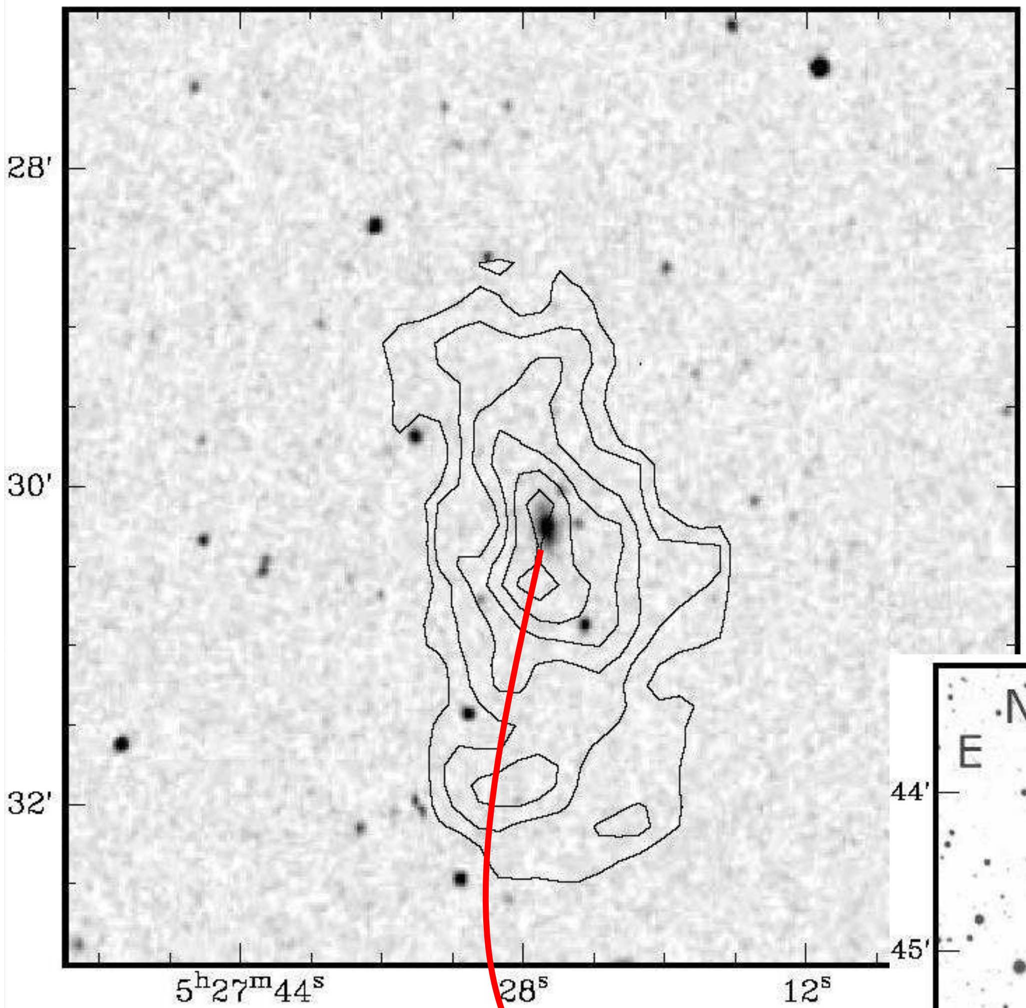
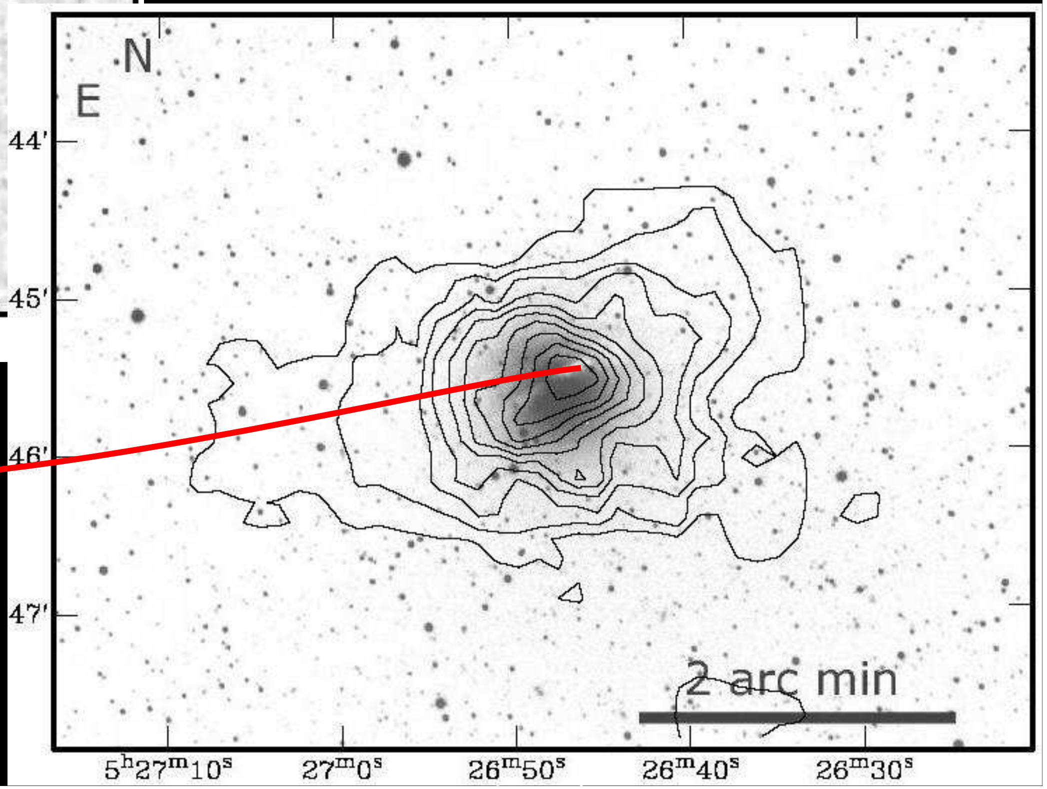
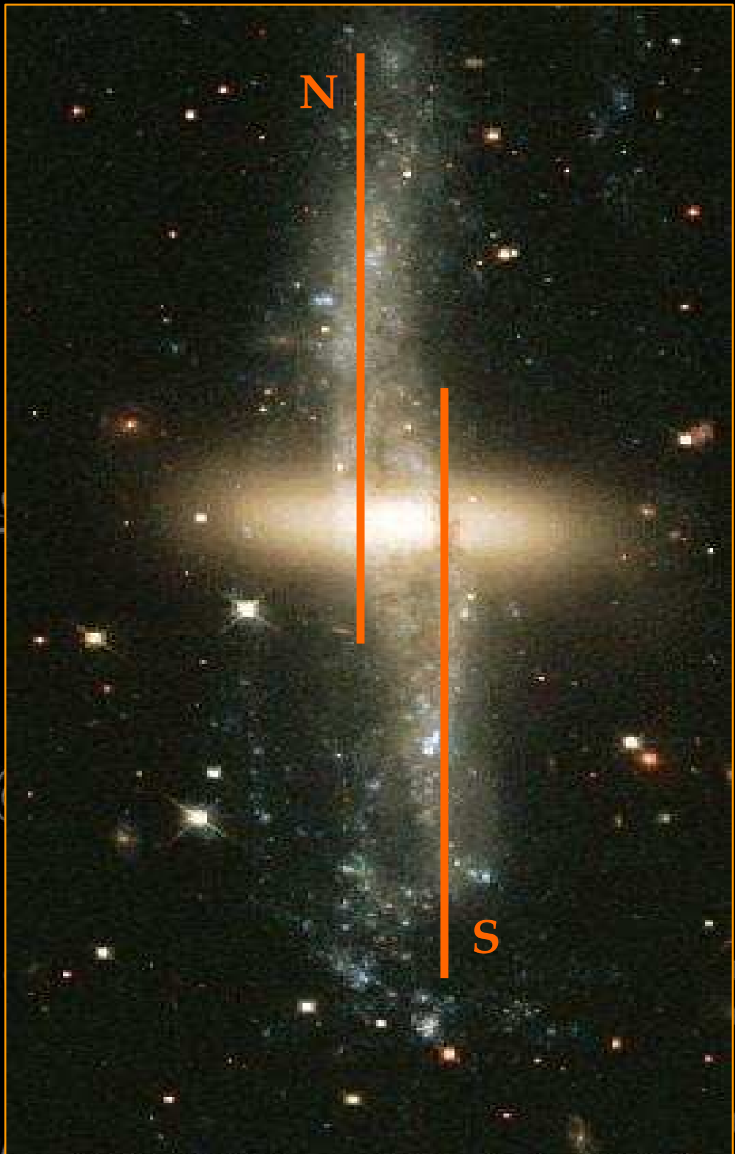
Oosterloo et al. 2002



HI emission of ESO 085-GA088 perpendicular to that of NGC1947 Orbital configuration needed to form a polar ring (of gas) through an accretion event.



The polar disk galaxy NGC4650A



- High resolution NIR and optical spectroscopy
- Measure of the abundances ratios and the metallicities of the HII regions in the polar disk of the galaxy.
- If the polar disk forms by accretion from cosmic web filaments of external cold gas, we expect the HII regions abundances and metallicities to be similar to those of late-type galaxies.
- If the metallicities are similar to those of early-type spiral galaxies, we would favor the accretion from a gas-rich donor.

"Spavone M., Iodice E., Arnaboldi M., Gerhard O., Saglia R., Longo G., In prep."

Work carried out @ ESO/MPE - Garching (Munich)

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Methods (1)

To reach our scientific goal, we measured Oxygen and Sulphur abundance parameters:

$$R_{23} = \frac{[OII]\lambda 3727 + [OIII]\lambda 4959 + \lambda 5007}{H_{\beta}}$$

(Pagel et al. 1979)

$$S_{23} = \frac{[SII]\lambda 6717 + \lambda 6731 + [SIII]\lambda 9069 + \lambda 9532}{H_{\beta}}$$

(Diaz et al. 2000)

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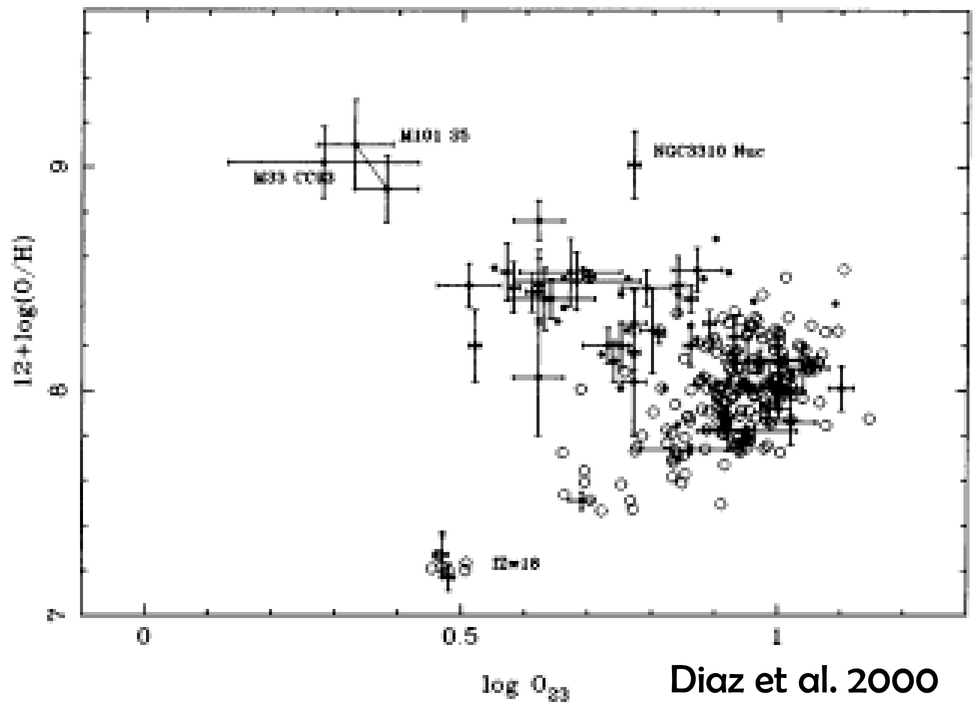
Methods (2)

We need to use both indicators to break the degeneracy with metallicity that affect R_{23} for values of $12+\log(O/H) \geq 8.0$



Diaz et al. 2000

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Abundancies and metallicities

I used the Sulphur abundance parameter S23 to calibrate the Oxygen abundance, by using the relation:

$$12 + \log \left({}^{O}\!/\!{}_{H} \right) = 1.53 \log S_{23} + 8.27$$

Diaz & Perez-Montero 2000, MNRAS, 312, 130

obtaining the following values:

Dereddened with Hγ

$$12 + \log \left({}^{O}\!/\!{}_{H} \right) \approx 8.35 \pm 0.10$$

Dereddened with Hα

$$12 + \log \left({}^{O}\!/\!{}_{H} \right) \approx 8.40 \pm 0.10$$

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Metallicities for the polar disk of NGC4650A

$$12 + \log \left({}^{O}\!/_{H} \right)_{sun} = 8.83 = A_{sun} \longrightarrow Z_{sun} = 0.02$$

$$12 + \log \left({}^{O}\!/_{H} \right)_{\gamma} \approx 8.35 = A_{\gamma}$$

$$12 + \log \left({}^{O}\!/_{H} \right)_{\alpha} \approx 8.40 = A_{\alpha}$$

Given that: $Z_{N4650A} \approx KZ_{sun}$

and $K = 10^{\left[A_{N4650A} - A_{sun}\right]}$

$K_{\gamma} = 0.33$

$K_{\alpha} = 0.36$

$\longrightarrow \begin{cases} Z_{\gamma} \approx 0.006 \approx 0.3 Z_{sun} \\ Z_{\alpha} \approx 0.007 \approx 0.35 Z_{sun} \end{cases}$

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Comparison with formation scenarios

Agertz et al. 2009 study the formation of disks at different redshifts by cold accretion processes.

They found that the cold accretion scenario reproduce the observed clumpy morphology and the global rotation.

They also found realistic metallicity gradient, star formation rate of 20 $M_{\odot}$/yr and disks with solar metallicities.

The metallicity of the clumpy regions are instead 1/10 of the solar one, due to the accretion of pristine gas in the cold streams mixing with stripped satellite gas.

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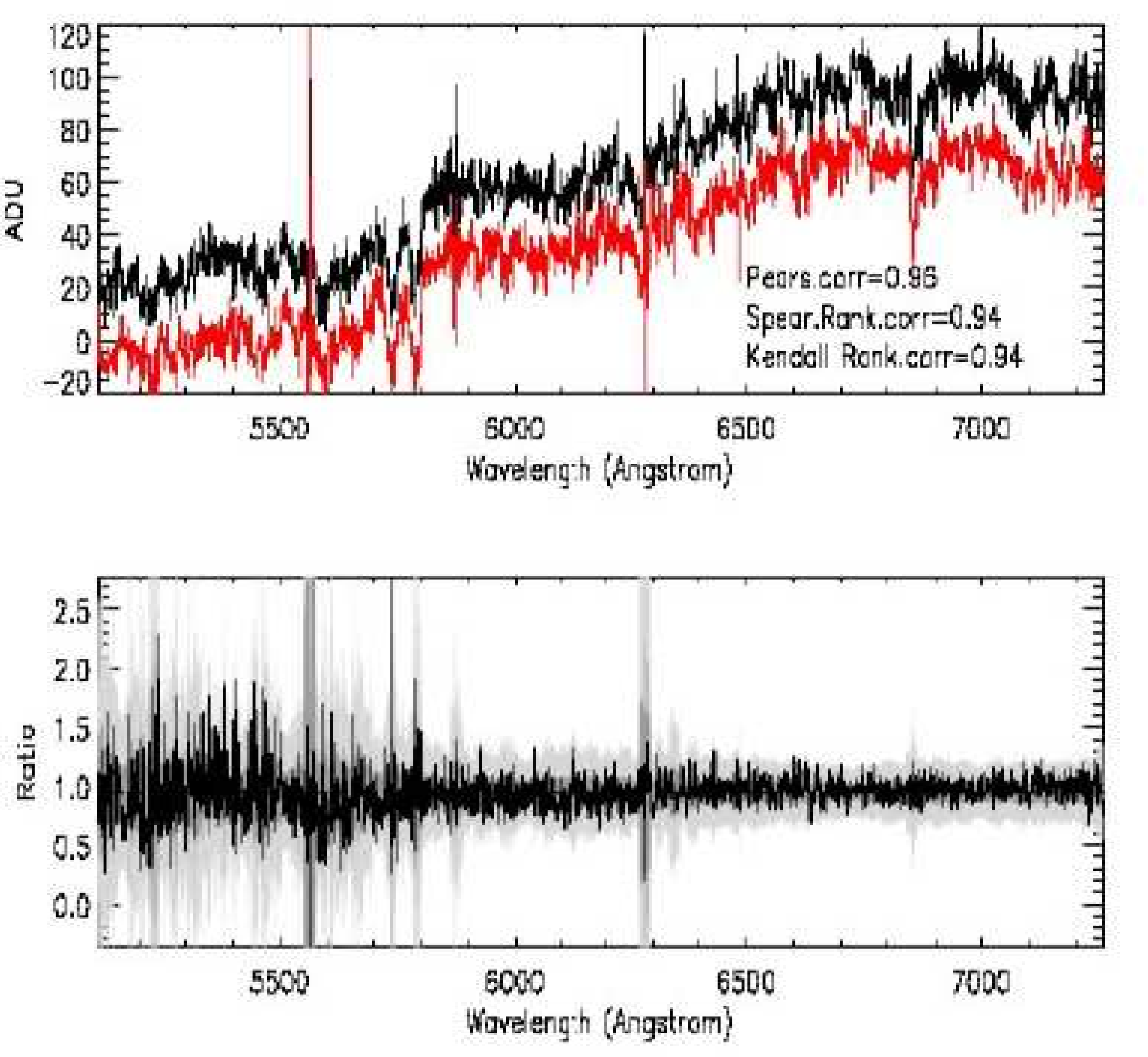
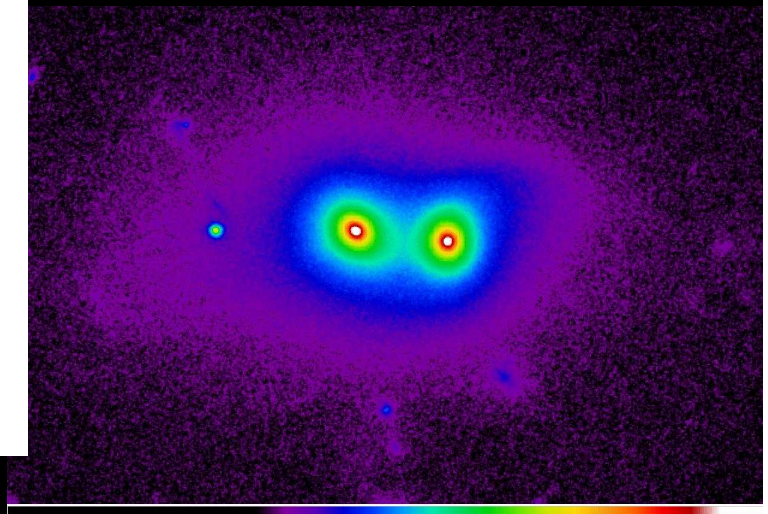
CSL1 – A possible dry merger



On January 12 of 2006, the Hubble Space Telescope (HST) observed the peculiar double extragalactic object CSL-1, suspected to be the result of gravitational lensing by a cosmic string. The high resolution image shows that the object is actually a pair of interacting giant elliptical galaxies.



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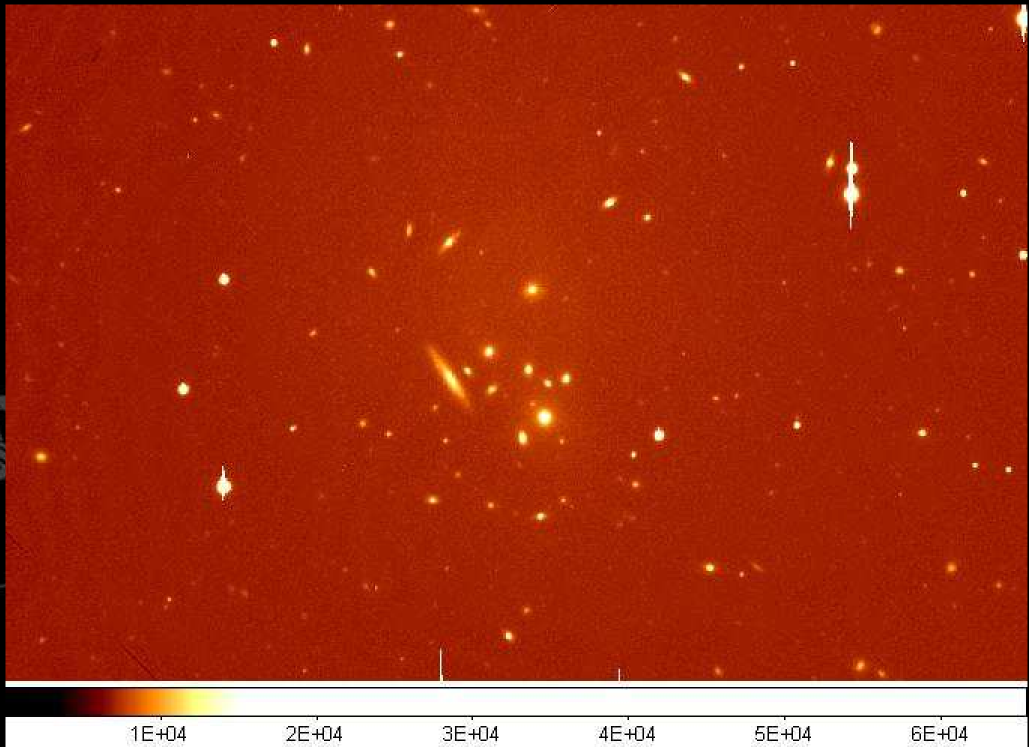
SHK groups

Poor groups of galaxies are the most common cosmic structures. In our recent study of the Shakhbazian (SHK) sample we reached the conclusion that they represent second generation structures whose evolution and morphological content depends on the environment in which they form. We thus are using MOS and long-slit observations of a sample of compact galaxy groups in order to constrain their mass, dynamical status and evolutionary timescales, together with the spectral properties of their members.



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Thank you

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