Searching for Chemical Abundance Gradients in Ring Galaxies

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Outline

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- Motivation
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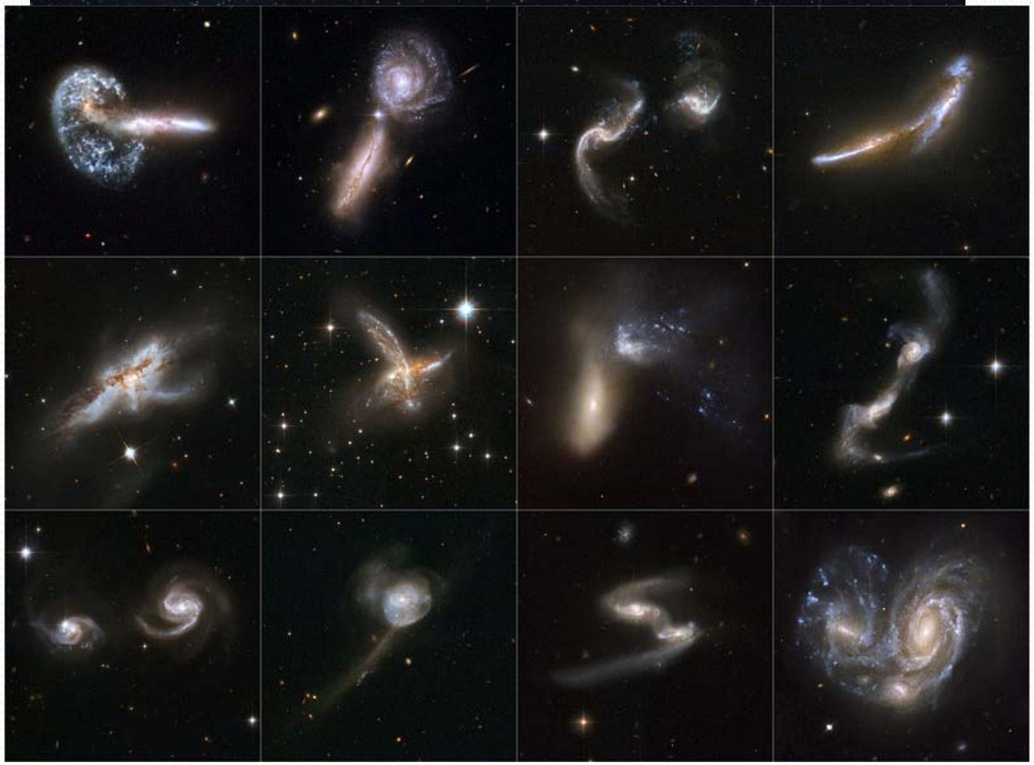
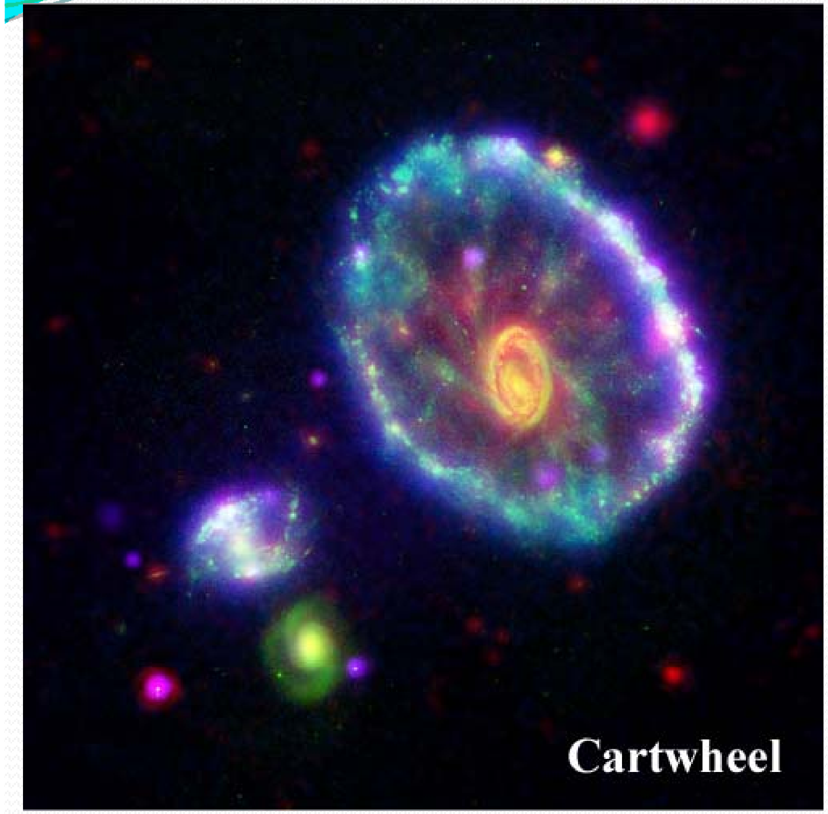
Introduction



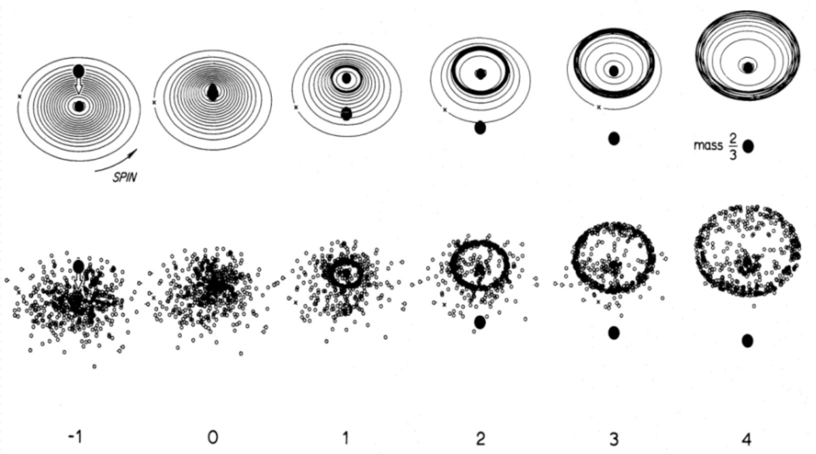
Ring Galaxies



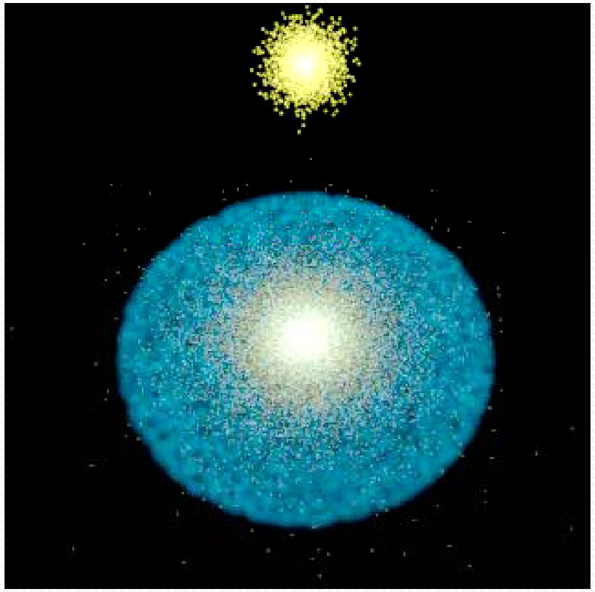
Lynds & Toomre (1976)

Theys & Spiegel (1977)

Explained the origin of Ring galaxies using numerical simulations: a result of axial collision between two galaxies.



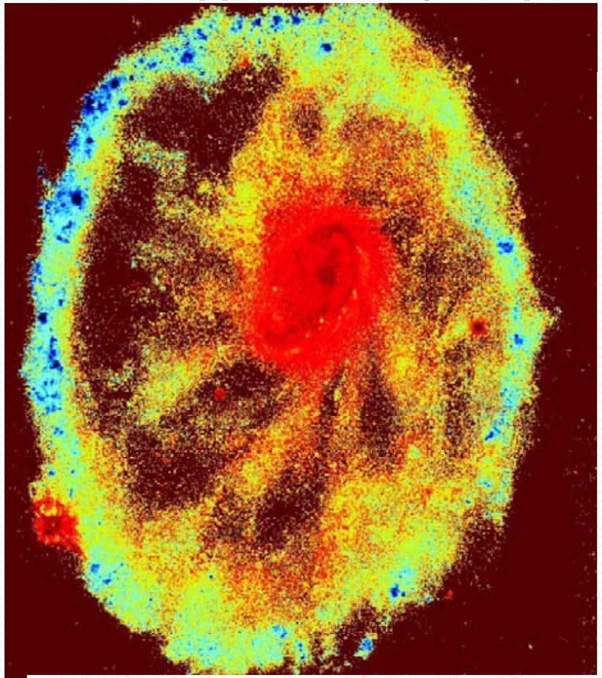
Cannon (1970): RGs are blue and have close companions.



Observational evidence:

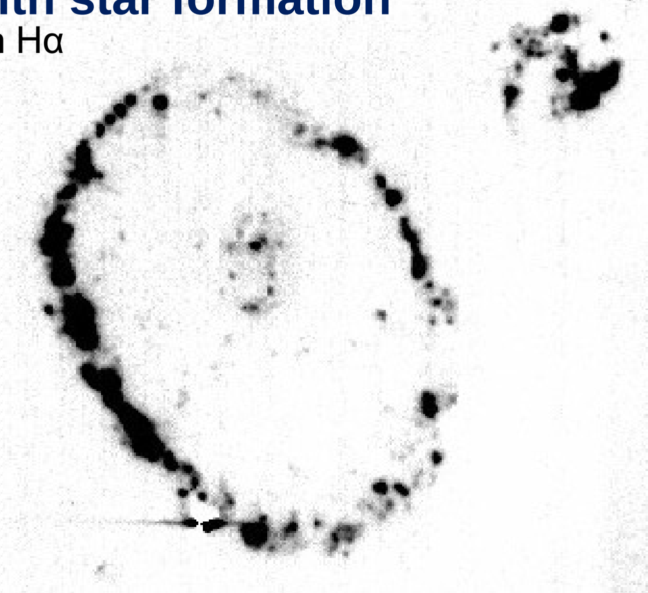
Color Gradients B-I (HST)

Marcum, Appleton & Higdon (1992)



Ring with star formation

Cartwheel en Hα
CFHT



Expansion of the ring

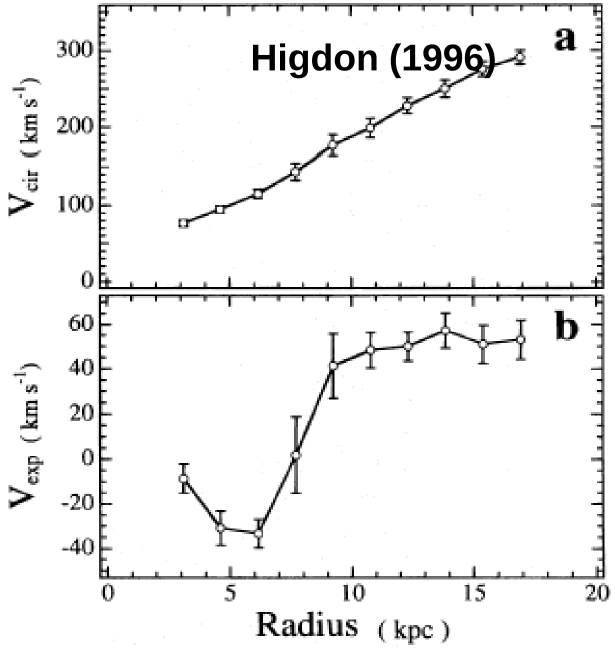
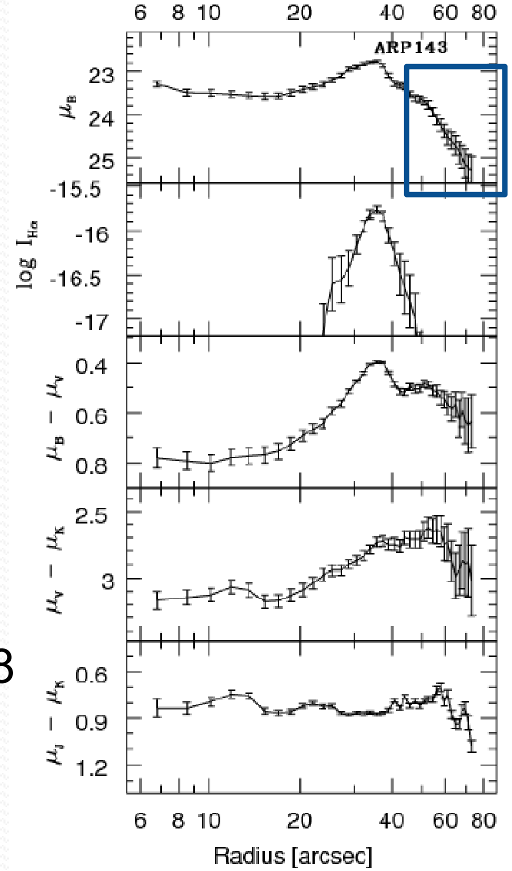


FIG. 11.—Derived (*a*) rotation curve and (*b*) variation in expansion velocity with radius from the model fits. The inner and outer rings are ated at radii of 3.7 and 16.5 kpc, respectively.

Vexp = 53 km/s, H1 (21 cm)

Ring is created by outward propagation of wave (~50-100km/s) triggering SF. Propagation time typically 100-300 Myrs to disk edge

Radial intensity profiles



Romano et al. 2008

Motivation:

Ring galaxies have a dynamical age of about 100-350 Myr. The collisional models predict a radial stellar age and metallicity gradients within the interior of the ring. No systematic study in this respect has yet been undertaken.

Existing spectroscopy work typically includes a few SF knots along the ring only, leaving aside the crucial aspect of the abundance pattern interior to the SF ring.

We want to explore the chemical abundance pattern of the RGs, to obtain new insights on the evolution of strongly interacting galaxies. This will help us improve and constrain better the models.

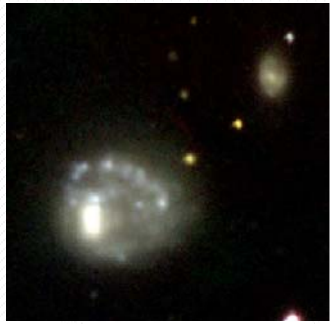
The Sample

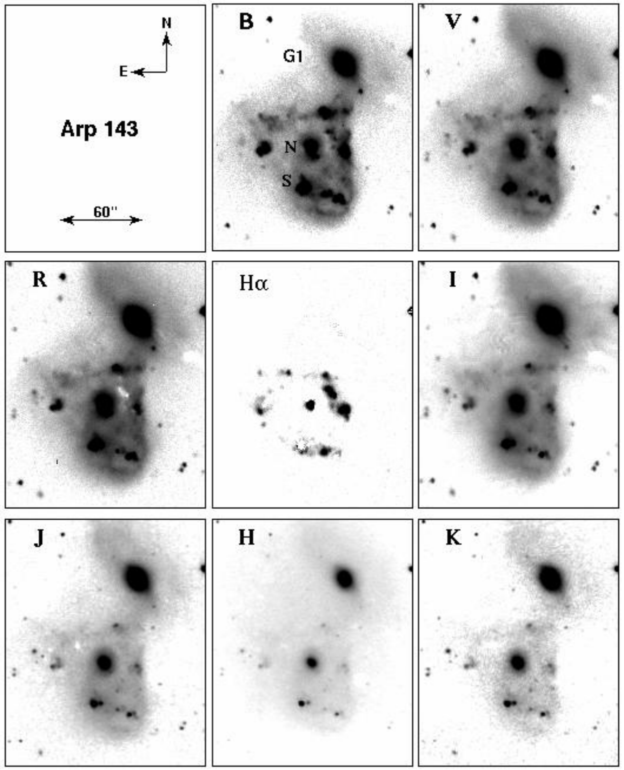
From the northern hemisphere we can observe 10-12 RGs, from which we can choose to perform our study:

Galaxies with evident ring morphology and emission inside the ring

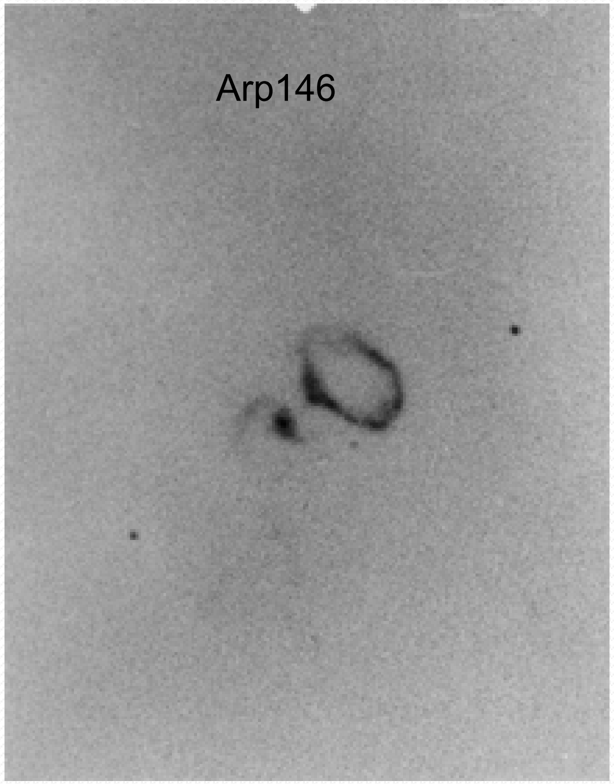
► Large angular size in order to identify internal SF regions

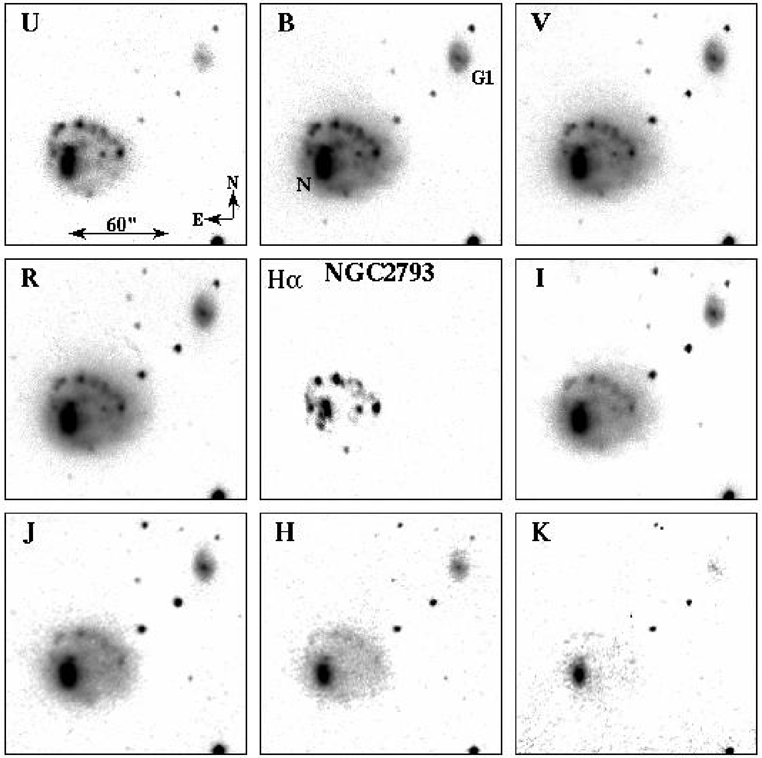
We have observed 4 RGs and are planning to observe 4 more.





Romano et al 2008





Observations and reductions

Long slit Spectroscopy

NGC2793, Arp143, Arp146, Arp147 → TNG: Using DOLORES and the Grism LR-B.

The spectra covered the 3000-8430Å at a dispersion of 2.52Å/pix.

The slit width was 1” and the *seeing* [1’’.0 to 2’’.0]

T exp = 3x1200s and 3x1000s

November 2009.

NGC2793 → INT: using an Intermediate Dispersion Spectrograph.

A slit 3´ long and 1”.5 wide was used.

The spectra covered the 3600 - 7300Å at a sampling of 1.85Å/pix.

The spatial sampling was 0”.39/pixel and the seeing ~ 2”.

Texp = 3x1200 s and 3x1000 s on April 2002.

Data reduction was done using **IRAF** (Image Reduction and Analysis Facility).

Empirical Calibrators of Chemical Abundance

Abundance of Oxygen:

12+log(O/H)= 0.79I*(NII) + 9.07

Pérez-Montero & Contini (2009)

The McGaugh(1991) calibration of R23, and we used the analytical expressions for the M91 lower and upper branches given in Kobulnicky et al. (1999). The estimated accuracy is ~ 0.13 dex

$$12 + \log(\mathrm{O/H})_{\mathrm{lower}} = 12 - 4.944 + 0.767x + 0.602x^2 - y(0.29 + 0.332x - 0.331x^2), \quad \text{(A1)}$$

$$12 + \log(\mathrm{O/H})_{\mathrm{upper}} = 12 - 2.939 - 0.2x - 0.237x^2 - 0.305x^3 - 0.0283x^4 - y(0.0047 - 0.0221x - 0.102x^2 - 0.0817x^3 - 0.00717x^4), \quad \text{(A2)}$$

where $x = \log R_{23} = \log[([\mathrm{O\ II}]\ \lambda3727 + [\mathrm{O\ III}]\ \lambda4959 + [\mathrm{O\ III}]\ \lambda5007)/\mathrm{H}\beta]$ and $y = \log O_{32} = \log[([\mathrm{O\ III}]\ \lambda4959 + [\mathrm{O\ III}]\ \lambda5007)/[\mathrm{O\ II}]\ \lambda3727]$.

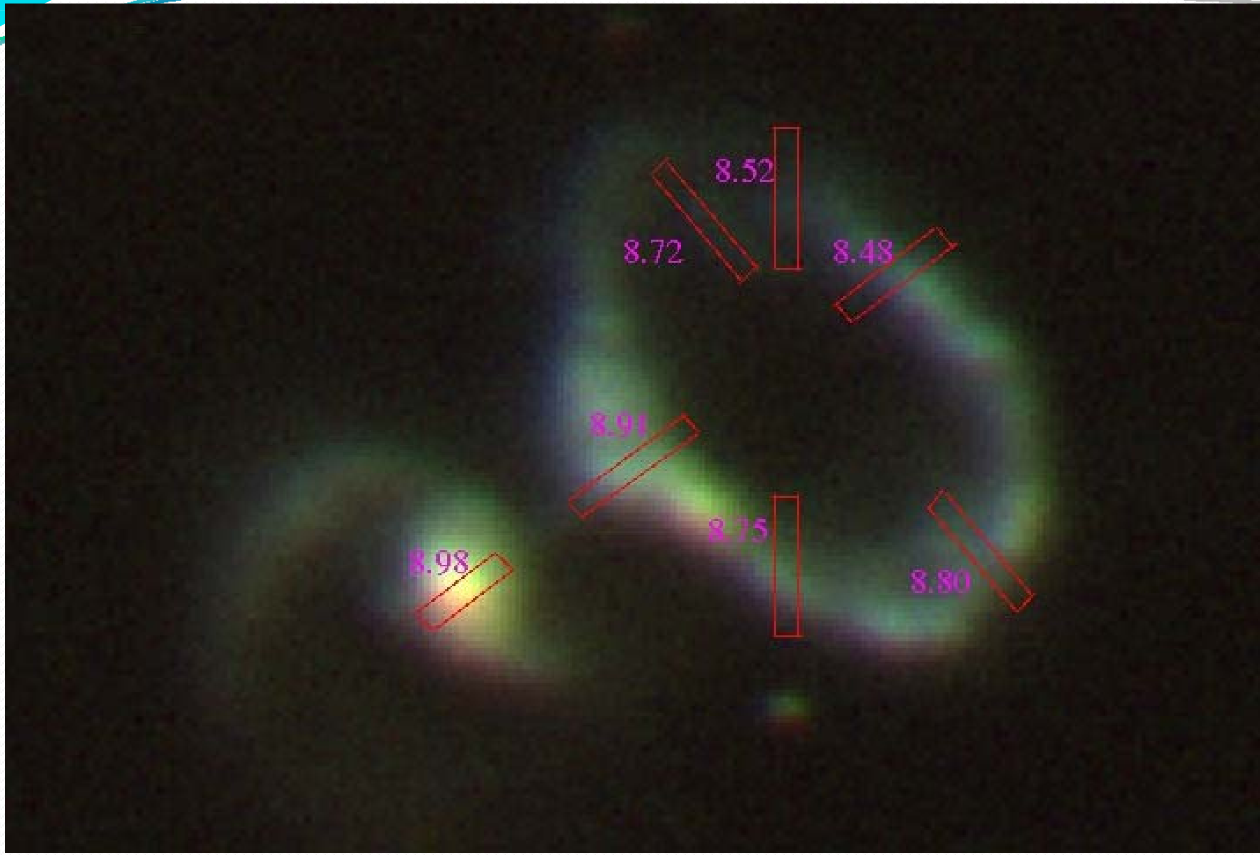
Abundance of Nitrogen

Log(N/O)=- 0.756+1.94z+0.5477z^2

where z=log[NII*6583 / (6716SII + 6731*SII)]

Pérez-Montero & Contini (2009)

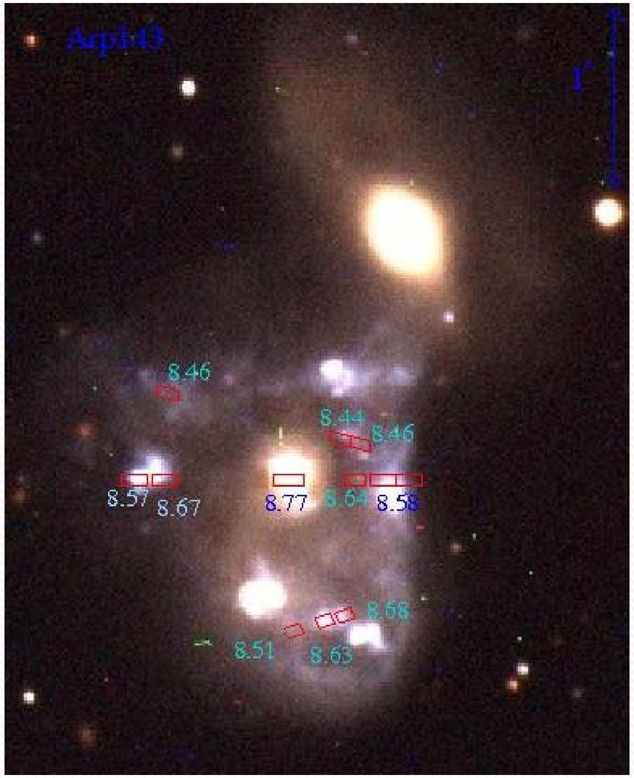
Preliminary Results: Arp146

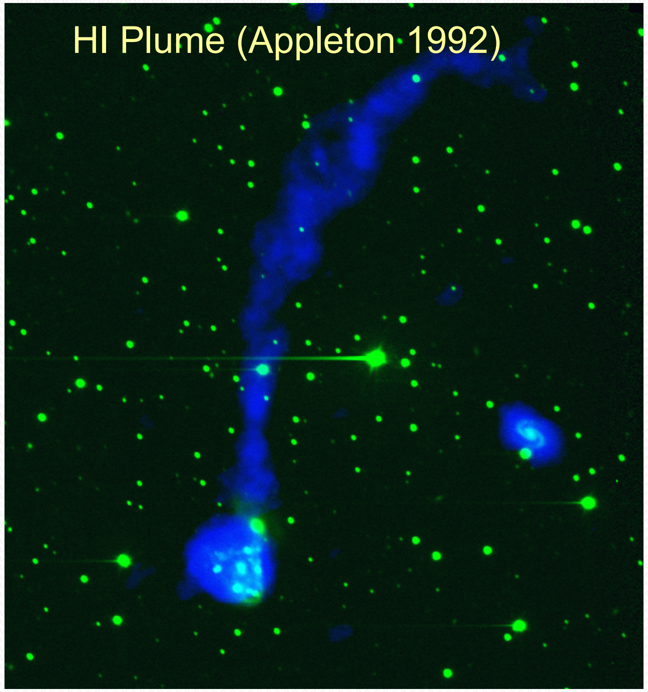


12+Log(O/H)=8.73, Δ=0.25
Mediana=8.75, Δ=0.27

Preliminary Results: Arp143

Galaxy	$R_{B25}('')$	B	$B-V$	$B-R$	$V-I$	$V-K$	$J-K$	$H-K$	M_K (mag)	M_* ($10^{10}\,M_\odot$)	M_{gas} ($10^{10}\,M_\odot$)	SFR(FIR) ($M_\odot$/yr)
Arp 143	70	13.30 ± 0.08	0.57 ± 0.02	1.22 ± 0.02	0.99 ± 0.01	2.93 ± 0.06	0.87 ± 0.01	0.28 ± 0.01	-23.86	6.05	1.34	5.60





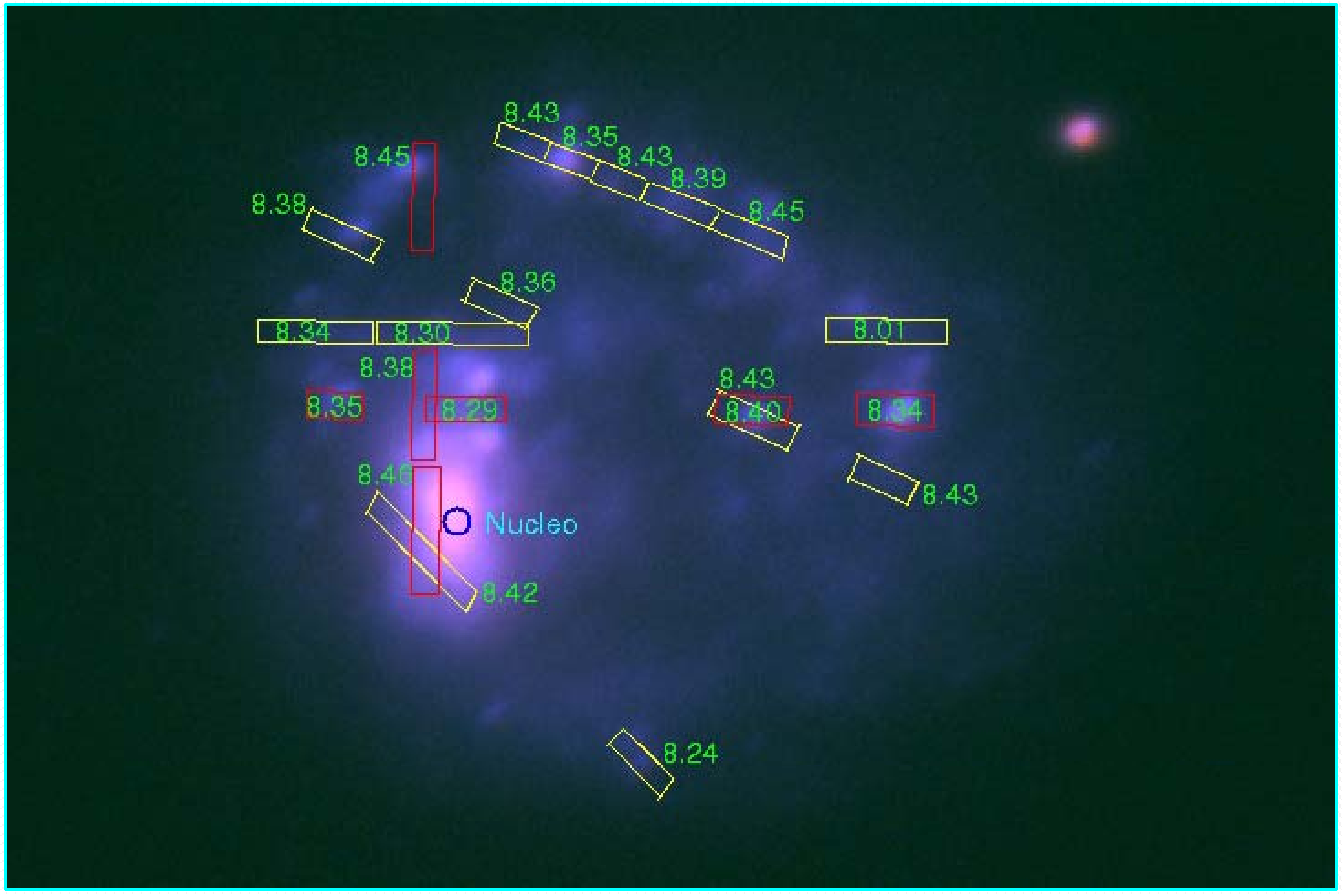
12+Log(O/H)=8.58, Δ=0.19
Mediana=8.58, Δ=0.19

V_exp=118±30 km/s Higdon et al. (1997)
R_ring=10 kpc
T_exp= 85 Myr.

$M_{RG}=M_C$

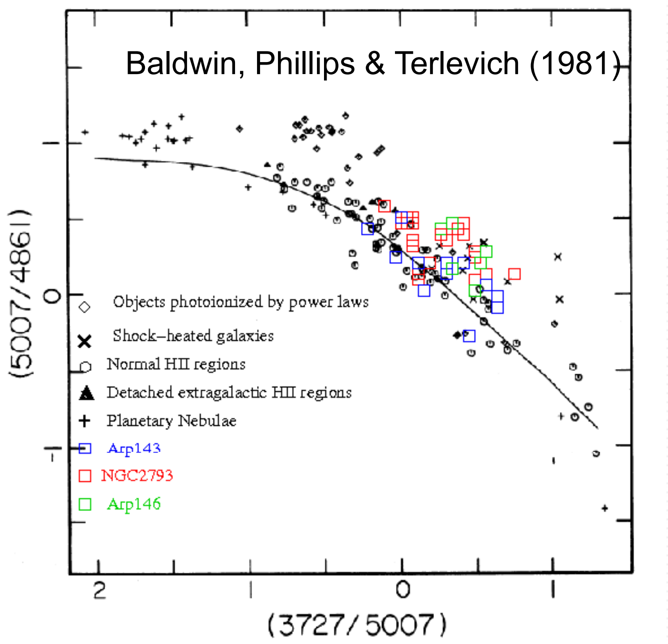
Preliminary Results: NGC2793

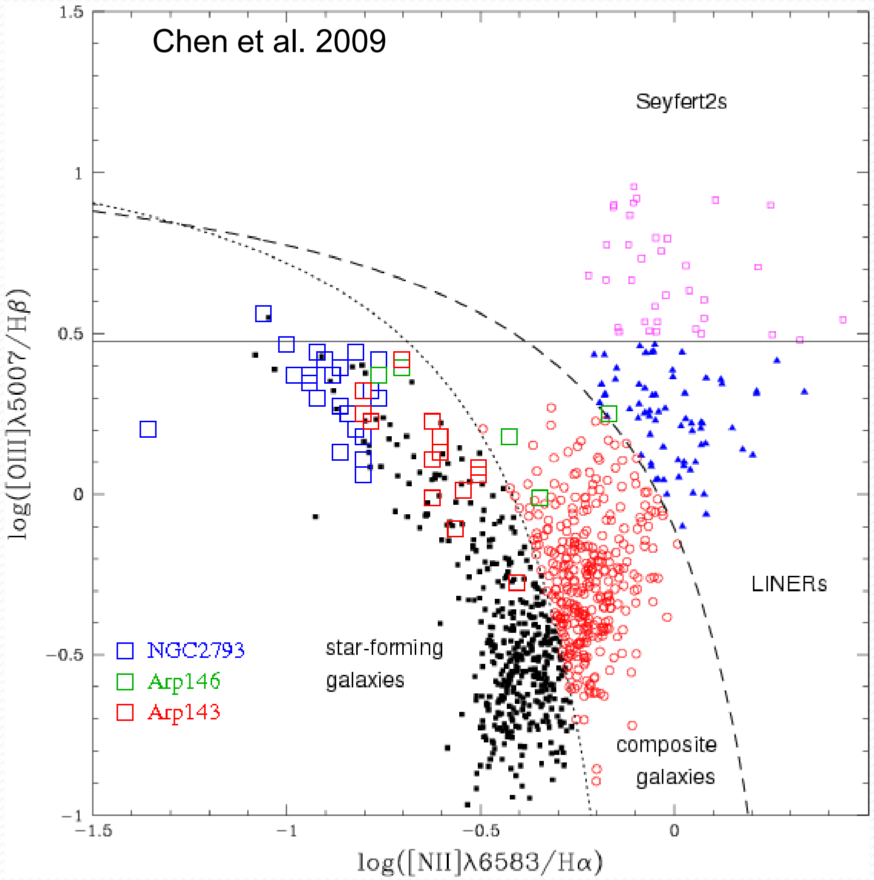
Galaxy	$R_{B25}('')$	B	$B-V$	$B-R$	$V-I$	$V-K$	$J-K$	$H-K$	M_K (mag)	M_* ($10^{10}\,M_\odot$)	M_{gas} ($10^{10}\,M_\odot$)	SFR(FIR) (M ® /yr)
NGC 2793	37	13.77 ± 0.04	0.38 ± 0.01	0.64 ± 0.01	0.75 ± 0.02	2.39 ± 0.05	0.96 ± 0.01	0.35 ± 0.01	−20.71	0.28	0.12	0.24



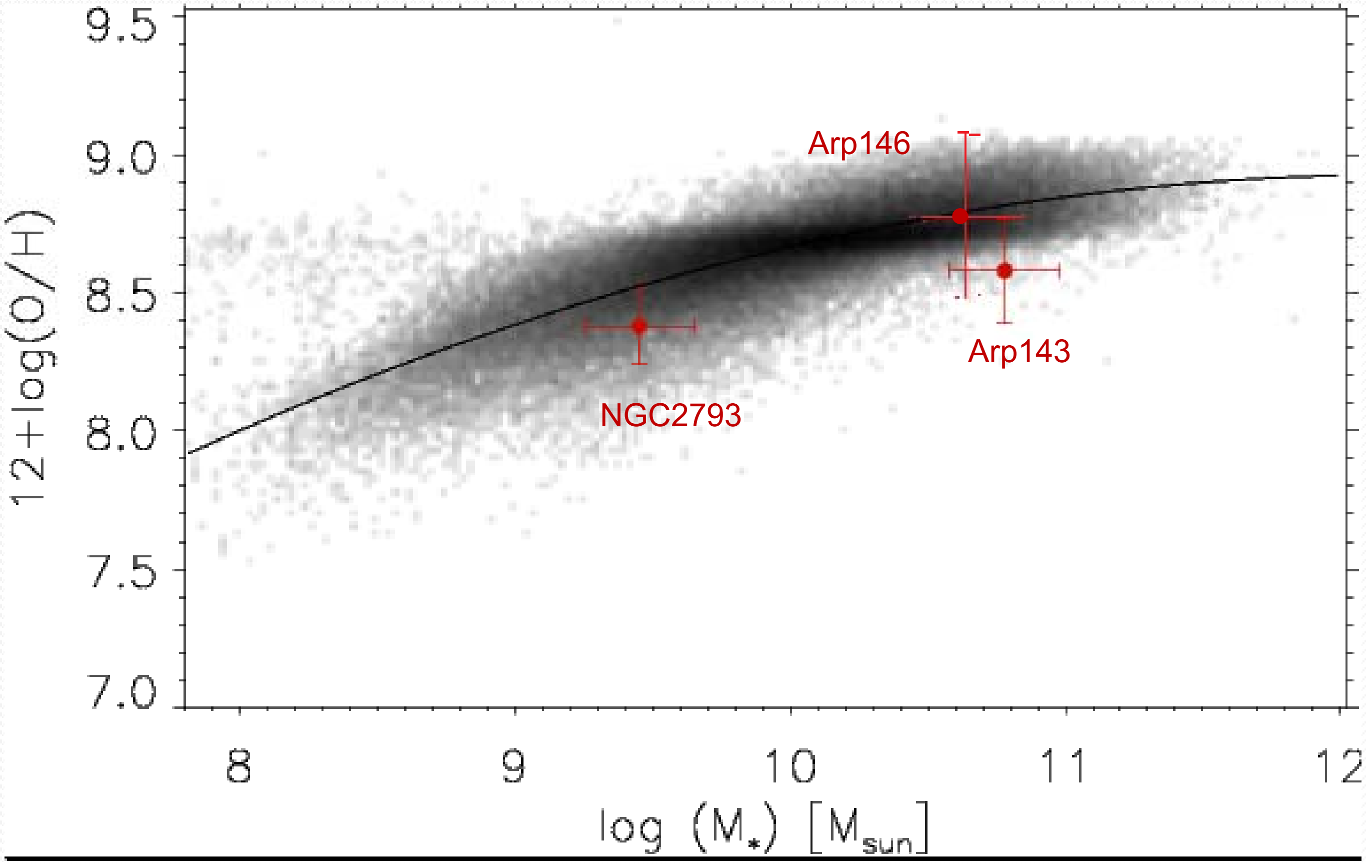
12+Log(O/H)=8.38, Δ=0.14
Mediana=8.38, Δ=0.14

BPT Diagrams





Mass- Metallicity relation



Conclusions:

- We have found spatial variations in the chemical abundance in the sample of ring galaxies.
- In Arp 146 we find an azimuthal O/H abundance gradient, a fact that has not been observed yet in a RG.
- The nucleus of the companion galaxy of Arp146 falls in the LINER part of the BPT diagram.
- Arp143 shows a radial abundance gradient, but the dynamical age of the ring indicates that we are observing probably the (spatial) redistribution of gas with pre-collision metallicities.
- In NGC2793 the O/H abundance is constant across the whole galaxy (ring and interior), including the nuclear region!!!!!. This result favours that the host galaxy is an irregular.
- The 3 RGs follow the same M-Z relationship as normal star-forming galaxies. They do not show an enrichment in O/H due to the interaction/collision. If such has occured it can not be observed yet.