

Programa 7: Abundancias y evolución química de galaxias con formación estelar

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ADB, JVM, CK, MMM, MGB, EA, DMG, LP, SSh



Introducción

- La evolución química es una de las herramientas básicas utilizadas en el estudio de las galaxias.
- Las abundancias de los elementos en el medio interestelar vienen determinadas por las masas eyectadas por las estrellas durante su evolución y muerte.
- Composición directamente relacionada con las historias de formación estelar
- Combinación de técnicas: modelos de evolución química + síntesis evolutiva de poblaciones estelares + modelos de fotoionización, como herramienta para discriminar entre las posibles historias evolutivas



Objetivos

- **Mantener la puesta al día del código multifase. Inclusión del cálculo de nuevos elementos.**
- **Establecer el impacto de los modos de formación estelar (instantáneo, continuo o recurrente) sobre la evolución química de las galaxias, combinando modelos de evolución química con modelos de síntesis evolutiva y con modelos de fotoionización.**
- **Analizar el impacto de los vientos debidos a explosiones supernova en la evolución química de las galaxias y determinar, a partir de la comparación con datos, en qué casos este escenario es necesario.**
- **Determinar la historia de la formación estelar en la muestra de galaxias starburst del proyecto comparando las predicciones de los modelos con las abundancias químicas medidas.**
- **Contrastar los resultados obtenidos con los que se obtienen mediante otras técnicas planteadas en otros programas, como por ejemplo, la evolución hidrodinámica.**

Metodología

	Prog. 1	Prog. 2	Prog. 3	Prog. 4	Prog. 5	Prog. 6	Prog. 7
Foto-ionización	X	x	X		X	X	x
Síntesis		X	X		X	X	x
Estructura			X	X	X	X	
Química	x		X		X	X	X

Objetivo 1: Mantener al día el código multifase

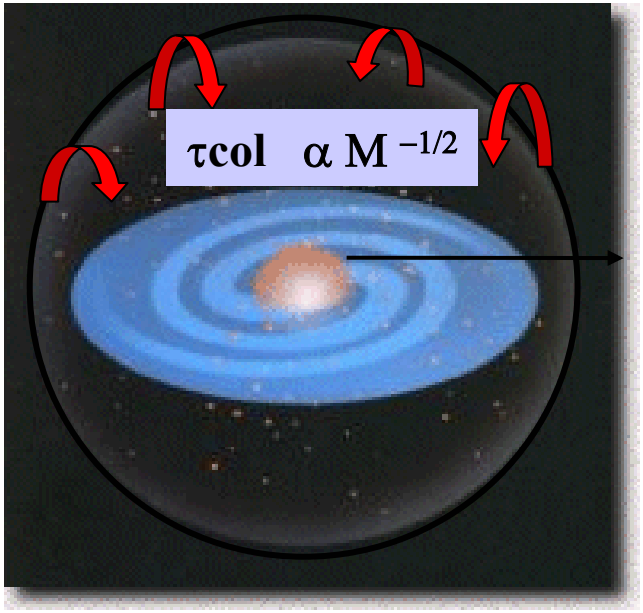
Todos estos trabajos implican la continua puesta al día de los códigos usados que, por otra parte, podrán también ser utilizados por otros programas del proyecto, en particular el modelo multifase de evolución química.

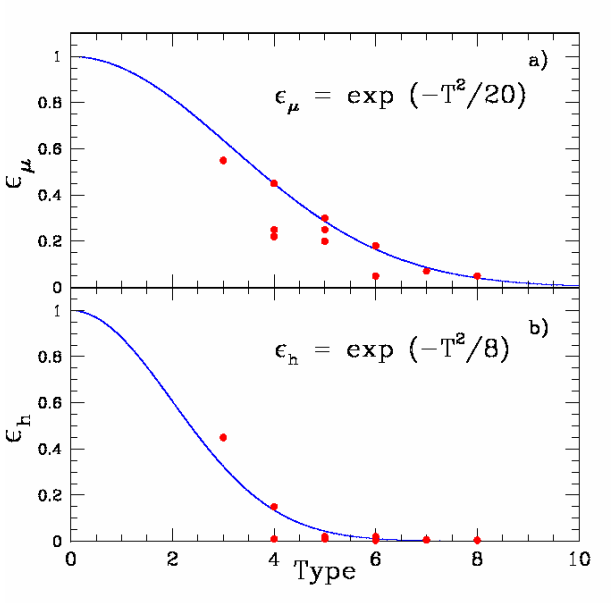
A grid of chemical evolution models

Mollá & Díaz (2005), MNRAS 358, 521

- The universal rotation curve from Persic, Salucci & Steel (1996): radial mass distribucions M (R)
- The collapse timescale for each distribution depends on mass:

$$\tau_{col,gal} / \tau_{col,MWG} = (M_{MWG}/M_{gal})^{0.5}$$





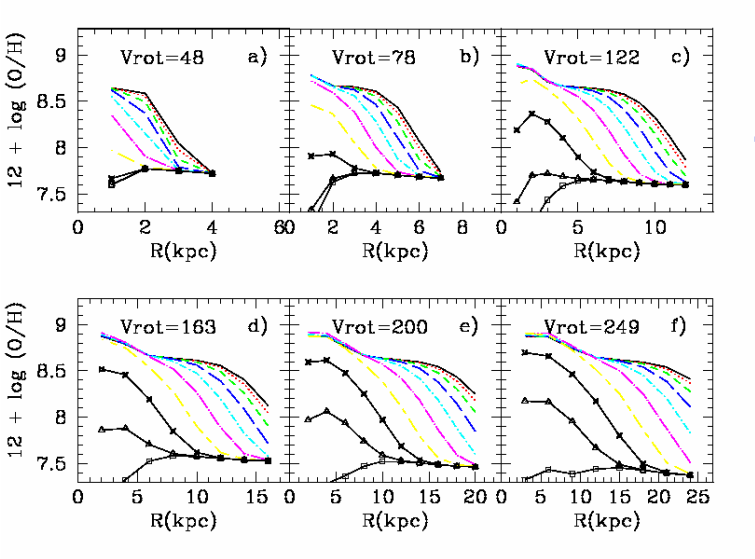
The star formation law depends on two parameters:

$$\Psi_D(t) = (H_1 + H_2)c_D{}^2(t) + (a_1 + a_2)S_{2,D}(t)c_D(t)$$

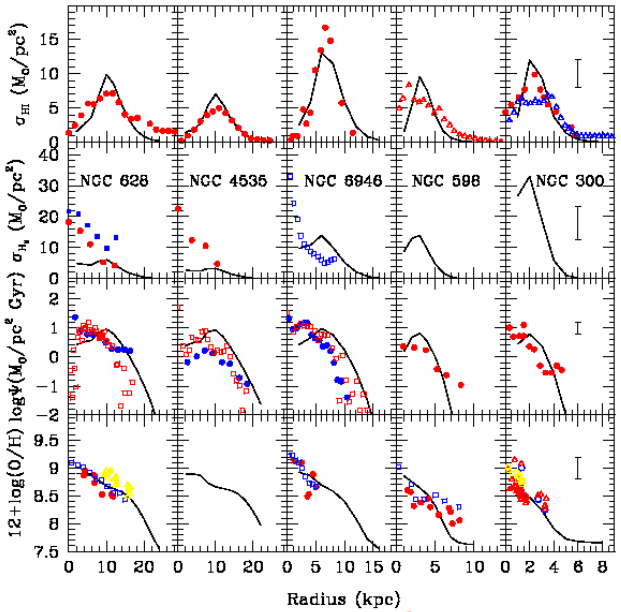
Analytical expressions for ε_μ (T) y ε_h (T)

Results of this chemical evolution model grid

- We compute models for 44 radial mass distributions, and 10 different values of eficiencies (ε_μ , ε_H) between 0 and 1, as it corresponds to their probability meaning, for each one = 440 different models
- The results of this bi-parametric grid can be applied to any spiral or irregular galaxy of given rotation velocity or total mass in order to estimate its evolution



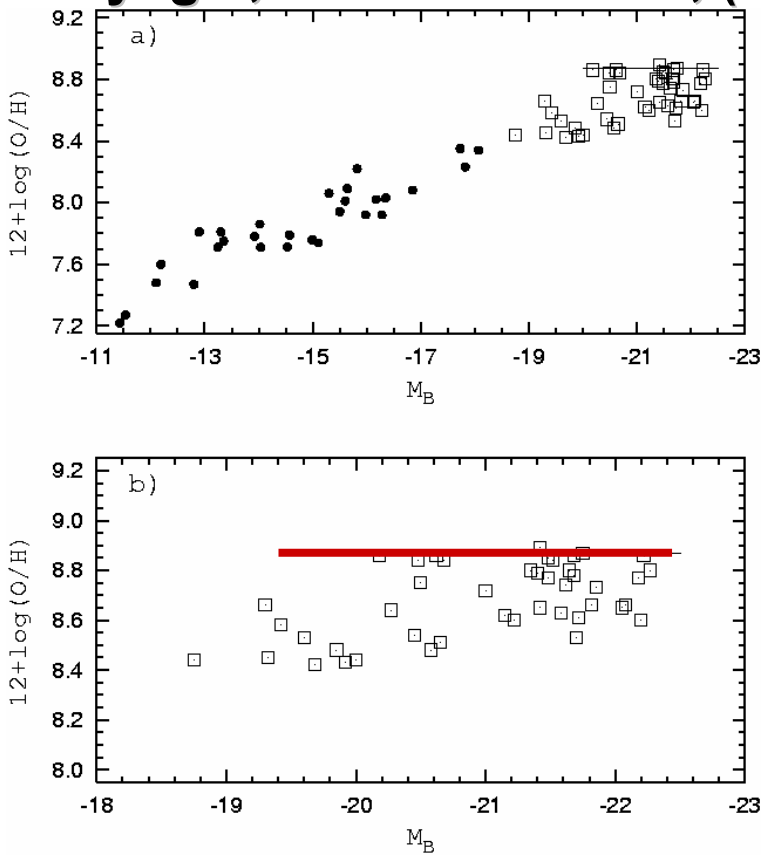
Results for particular galaxies



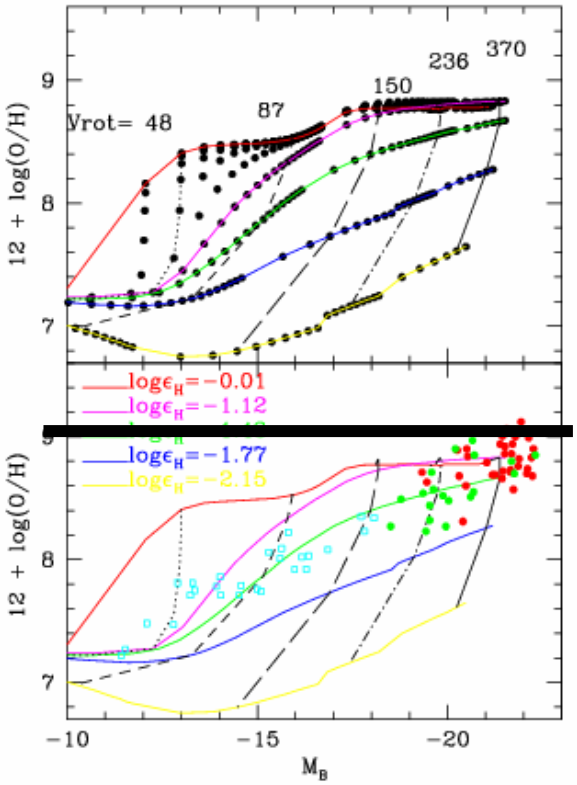
- **Time evolution for the calculated quantities in each radial region of the galaxies:** Star formation history and Age-metallicity relation
- **Radial distributions for every galaxy in each time step**

The maximum oxygen abundance

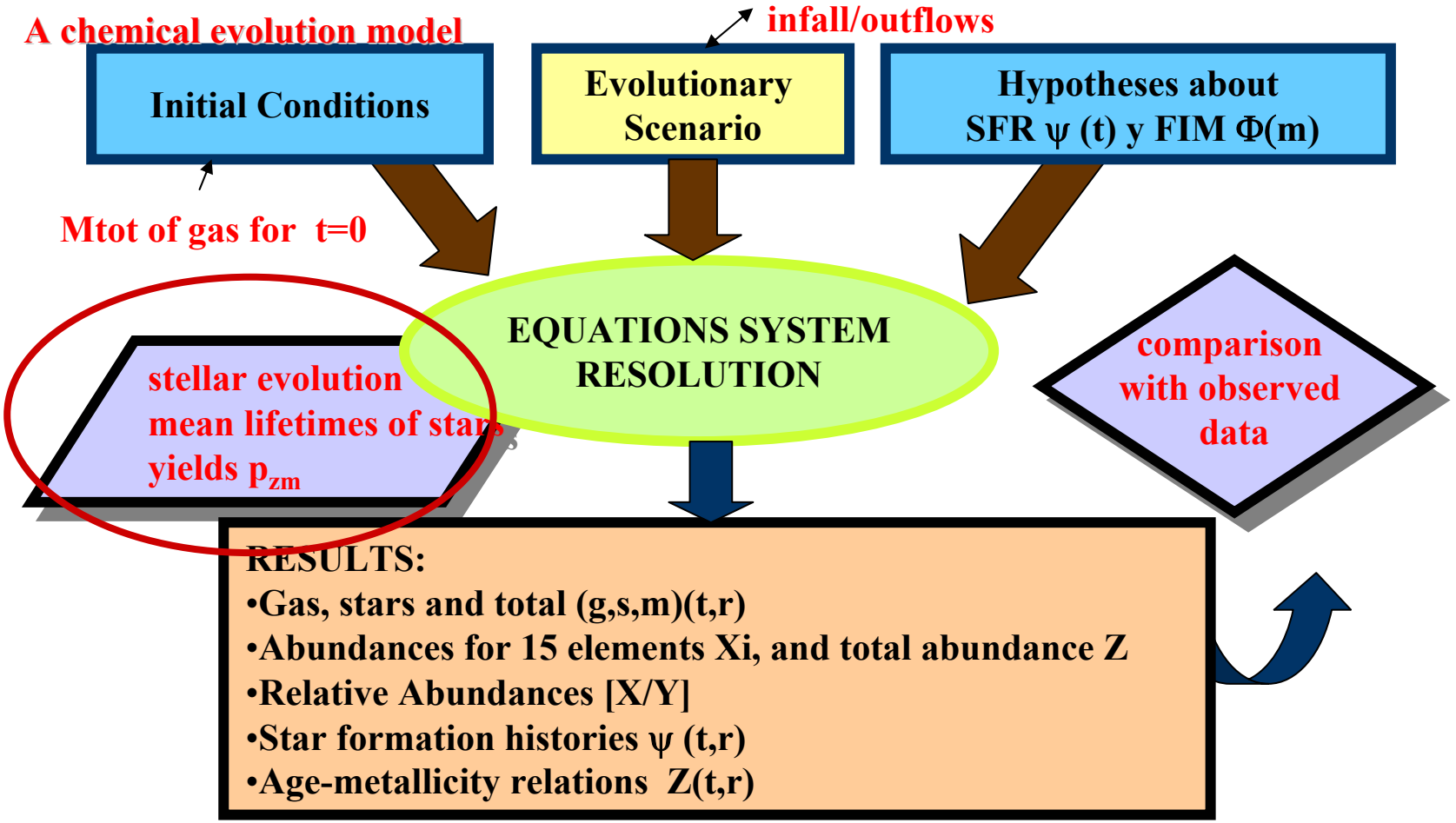
Pilyugin, Thuan & Vílchez, (2007)



Our models:

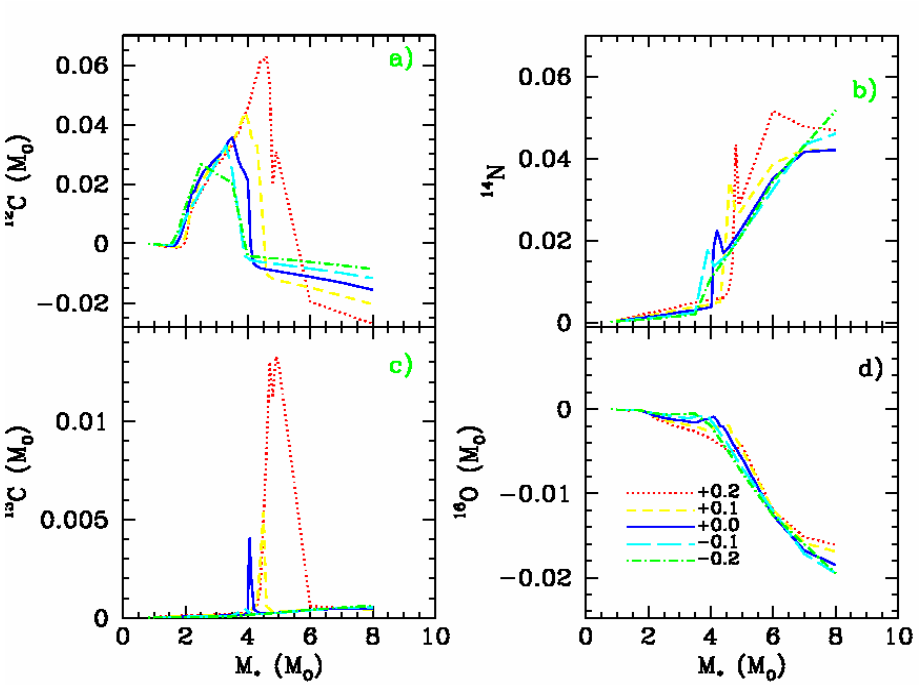


- **A partir de una amplia compilación de datos de regiones HII, valor máximo es 12 + log(O/H) ~ 8.95.**
- **Esto permite calcular el yield de oxígeno de una con bastante exactitud**


A chemical evolution model
infall/outflows
Initial Conditions
Evolutionary Scenario
Hypotheses about SFR ψ (t) y FIM Φ(m)
Mtot of gas for t=0
EQUATIONS SYSTEM RESOLUTION
stellar evolution
mean lifetimes of stars
yields p_{zm}
comparison with observed data
RESULTS:
•Gas, stars and total (g,s,m)(t,r)
•Abundances for 15 elements Xi, and total abundance Z
•Relative Abundances [X/Y]
•Star formation histories ψ (t,r)
•Age-metallicity relations Z(t,r)

Ingredients of the chemical evolution model: Nucleosynthesis prescriptions

Gavilán, Buell & Mollá (2005): new stellar yields for 0.8 Mo < m < 8 Mo



- The evolution of a LIM star during the TP-AGB phase is dominated mainly by the third dredge up events and the Hot Bottom Burning processes
- The first ones affect stars 2 Mo < M < 4 Mo, by increasing the C abundance.
- If M> 4Mo, the HBB produces an abrupt increase of N (with a proportion of primary N) and a decrease of C.

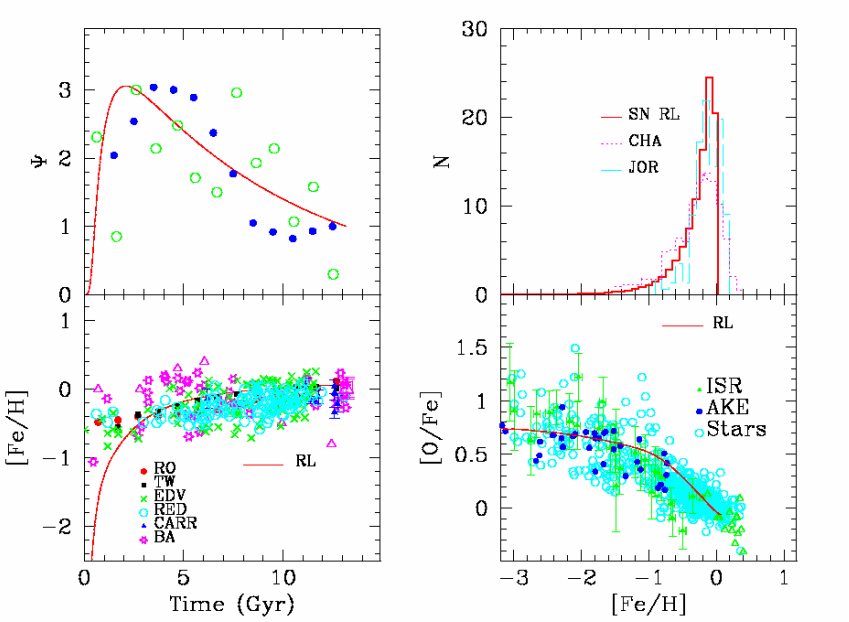
The mass loss depends on metallicity: it increases the time that the star spends on the TP-AGB allowing for more dredge-up events to occur, increasing the amount of primary C and N.

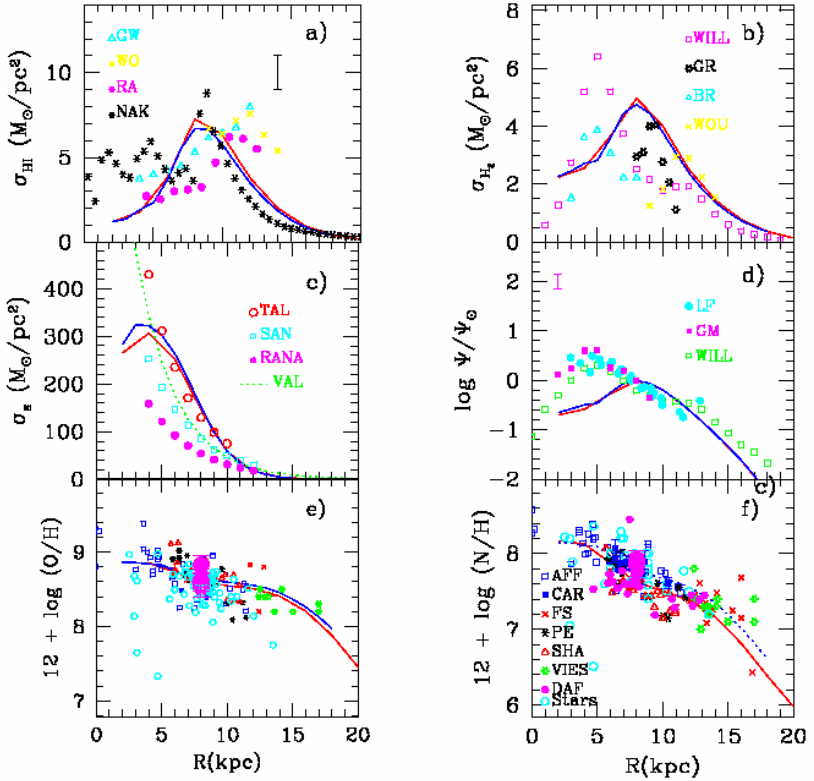
The HBB causes an increase of ^{14}N and a decrease of ^{12}C

Calibration for MWG

Gavilán, Mollá & Buell (2006)

- ✓ The age-metallicity relation and the star formation history for the solar region well fitted
- ✓ The metallicity distribution does not show the G-dwarf problem
- ✓ We can obtain separately the radial distributions of diffuse and molecular gas
- ✓ The radial gradients flattens in the inner disk in agreement with data (Smartt et al. 2001)
- ✓ The star formation rate surface density is underestimated in the inner radii



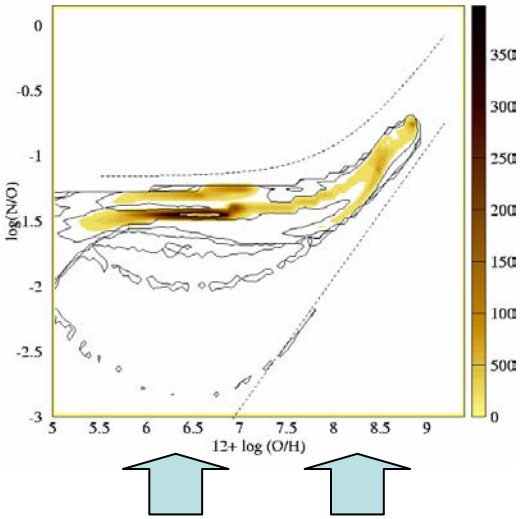


Estallidos de formación estelar en galaxias

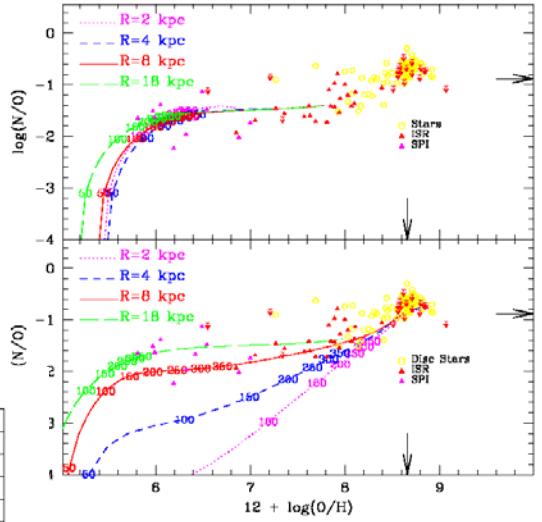
The nitrogen abundances

Mollá, Vílchez, Gavilán & Díaz (2006):

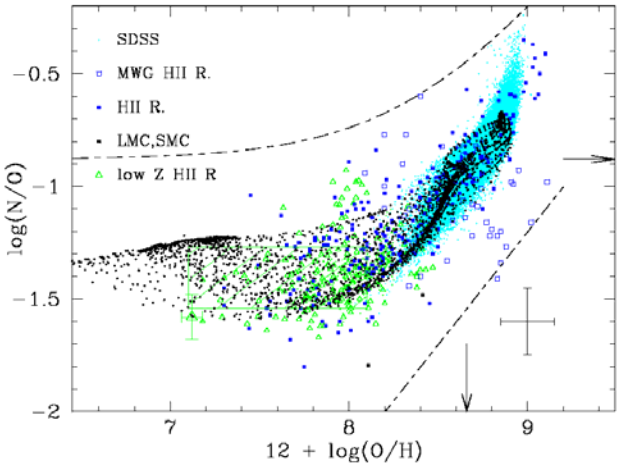
Using this grid of models, we have obtained these results in the plane N/O vs O/H for the whole set of models and all computed time steps



Results for the halo (top) and the disk (bottom) of MWG



Different time steps results: Something as a plateau appears in the results for high redshifts

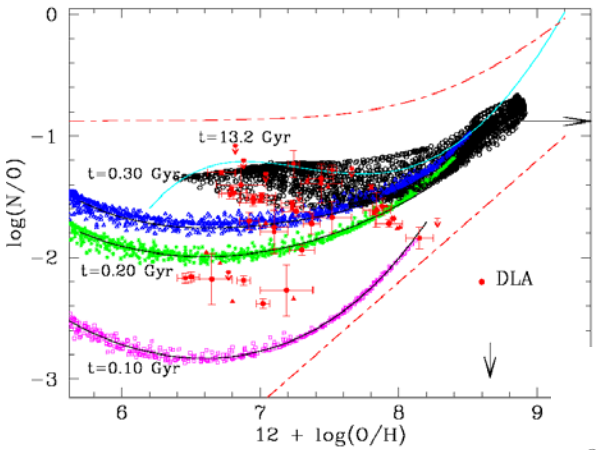


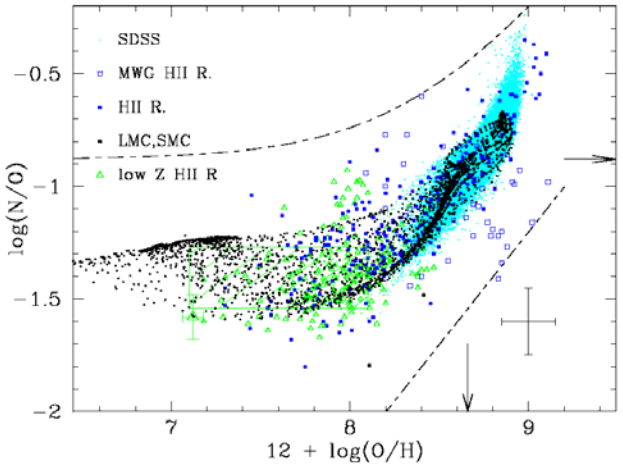
The present day abundances distribution in the plane N/O vs O/H compared with data from Galactic and extragalactic HII regions

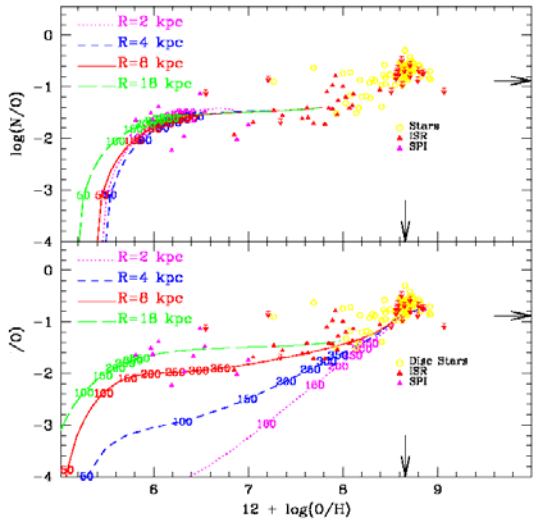
The nitrogen abundances

Mollá, Vílchez, Gavilán & Díaz (2006):

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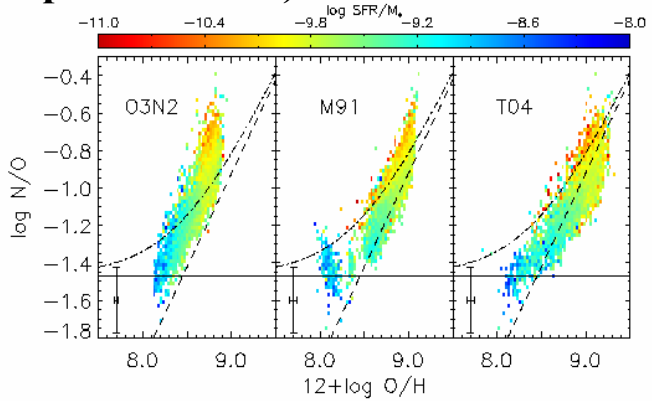


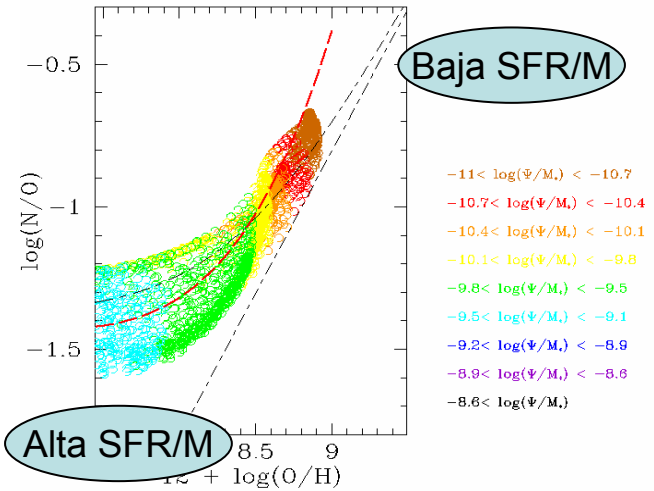
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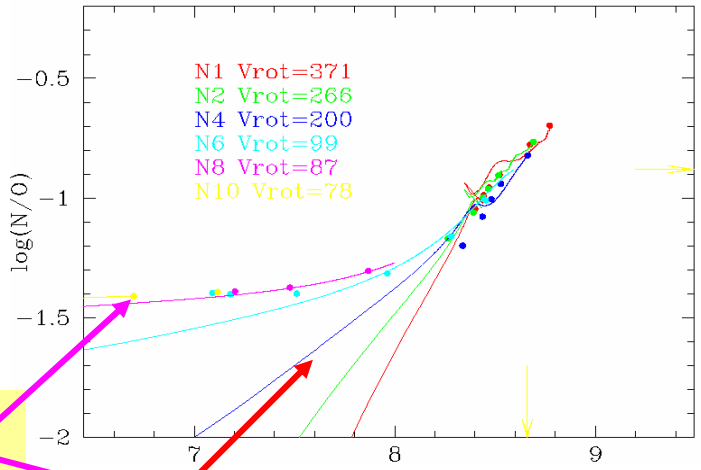
THE RELATION N/O-SFR-SFH (Mollá et al. 2007 in preparation)

Galex data (Mallery et al. 2007, astroph/0706.0238)

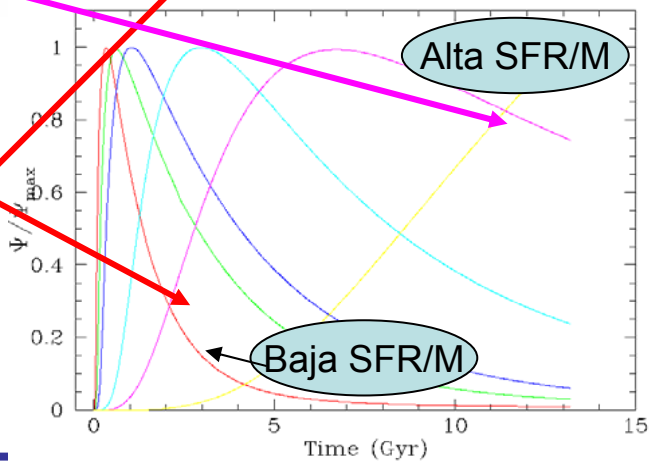




Time evolution of a region: Each line joins the different radial region results for a same time step



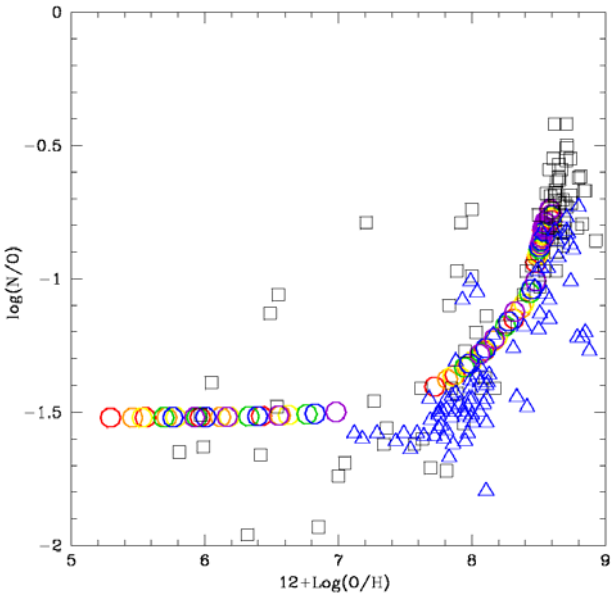
a) Tracks of the lowest mass galaxy with the smallest star formation efficiency.
b)Tracks of the most massive galaxy and the highest star formation efficiency.

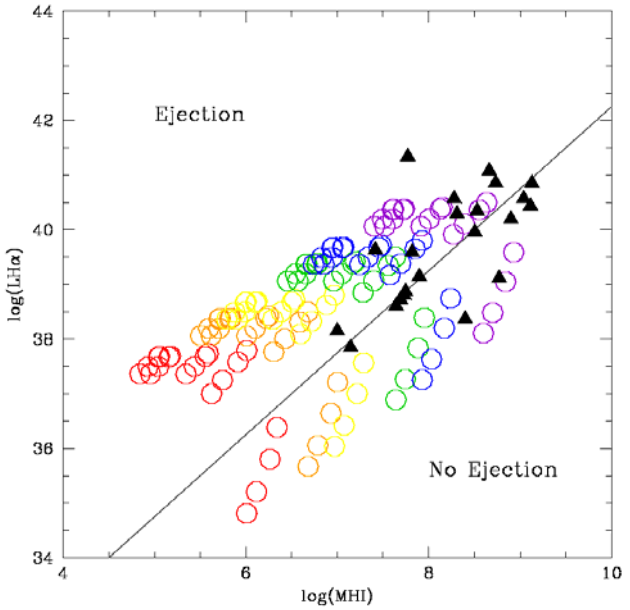


Chemical evolution of dwarf galaxies

Gavilán, Mollá & Vílchez (2007, in preparation)

- **We have developed a grid of chemical evolution models of dwarf galaxies using the low and intermediate mass stars yields from Gavilán et al. (2005,2006): the plateau of N/O appears naturally when the star formation occurs quietly**
- **We study the metallicity, the gas fraction and the star formation rate.**
- **We also obtain results about the gas loss: difficult to conclude**



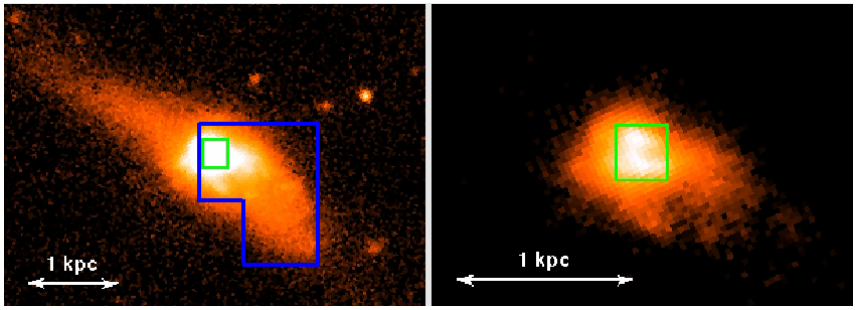


The interplay between ionized gas and massive stars in the HII galaxy IIZw70: integral field spectroscopy with PMAS

C. Kehrig, J. M. Vílchez, S. Sánchez, E. Telles, E. Pérez-Montero & D. Martín-Gordón

SUMMARY: The goal of this work is to perform an integral field spectroscopic study for the HII galaxy IIZw70 to investigate the interplay between its ionized interstellar medium (ISM) and the massive star formation

•Observations taken in the optical spectral range (3700 Å - 6800 Å) with the Potsdam Multi-Aperture Spectrophotometer (PMAS) attached to the 3.5 m telescope at Calar Alto Observatory.



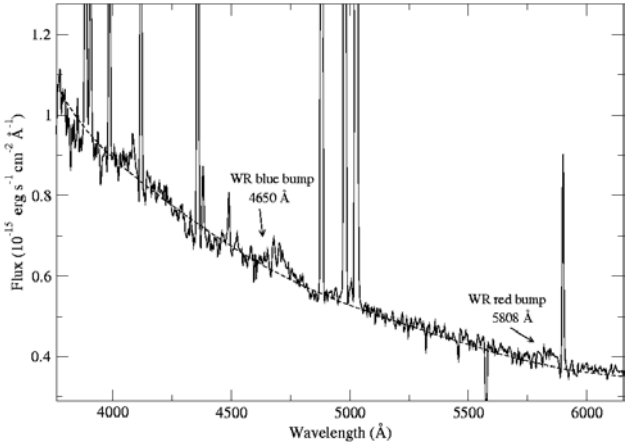
- Maps of spatially distributed emission-lines (at different stages of excitation), continuum emission, and properties of the ionized ISM (ionization structure indicators, physical-chemical conditions, dust extinction, kinematics).
- The relation of these properties to the spatial distribution and evolutionary stage of the massive stars.
- (see Kehrig et al. 2007/arXiv:0710.5732)

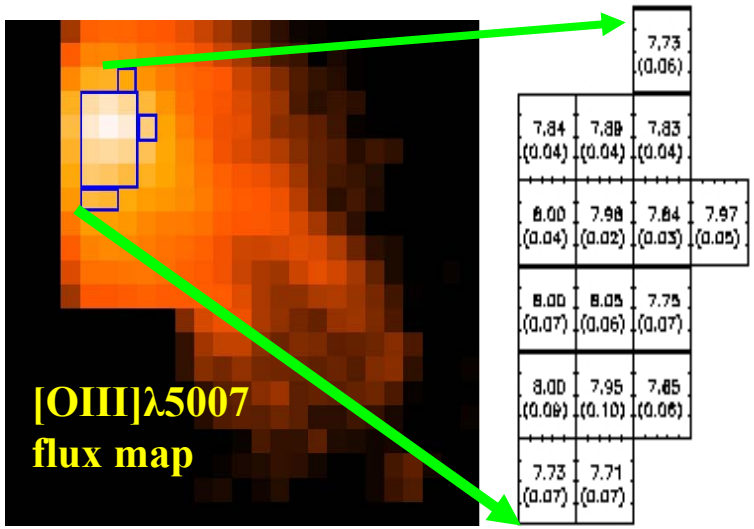
Results

- For the first time we have detected Wolf-Rayet (WR) stars in IIZw70.
- ●The region of the galaxy with lower dust extinction corresponds to the region that shows the lowest values of velocity dispersion and radial velocity. The overall picture suggests that the ISM of this region is being disrupted via photoionization and stellar winds, leading to a spatial decoupling between gas+stars and dust clouds.

● The bulk of dust appears to be located at the boundaries of the region occupied by the probable ionizing cluster. This indicates that the hard ionizing radiation responsible for the HeIIλ4686 nebular emission can be related to the youngest stars.

● Within ~ 0.4 x 0.3 kpc2 in the central burst, we derived O/H using direct determinations of *T*e[OIII]. We found abundances in the range 12+log(O/H)=7.65-8.05, yielding an error-weighted mean of 12+log(O/H)=7.86 ± 0.05.

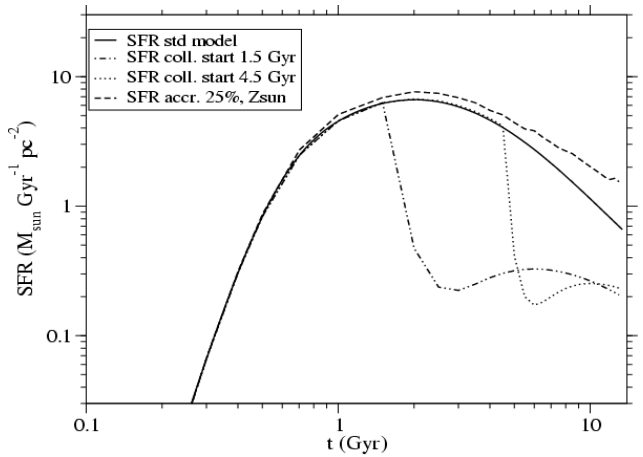


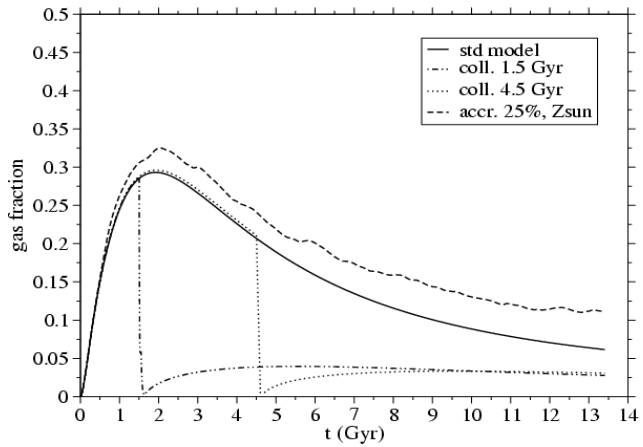


Is IIZw70 chemically homogeneous ?

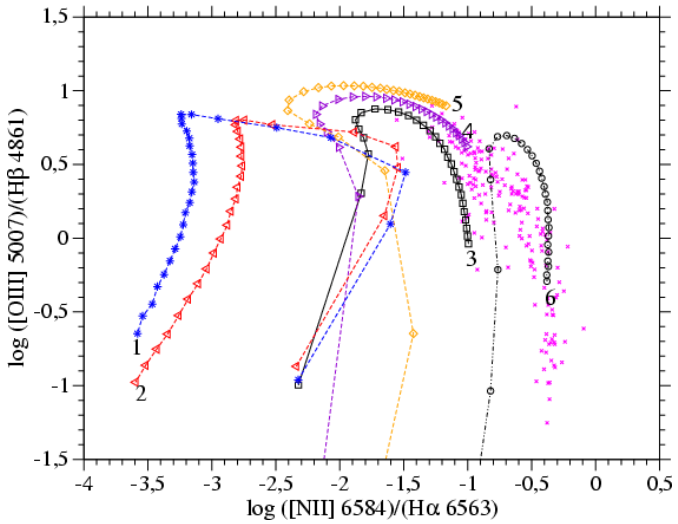
Chemo-population multizone models for emission line evolution of star forming galaxies

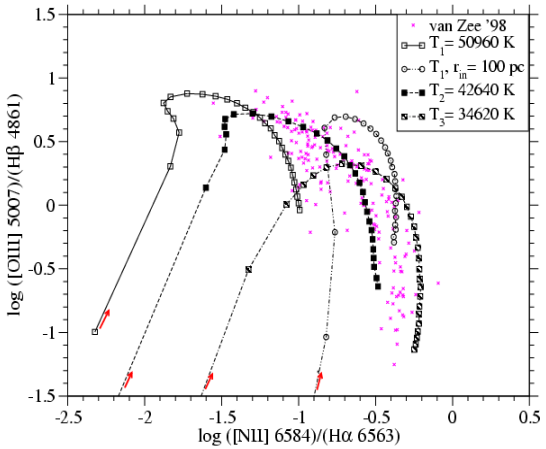
- **Valle & Shore (2007)** conclude that **a coupled treatment of the galactic population and chemical evolution is essential for interpretation of the data.**

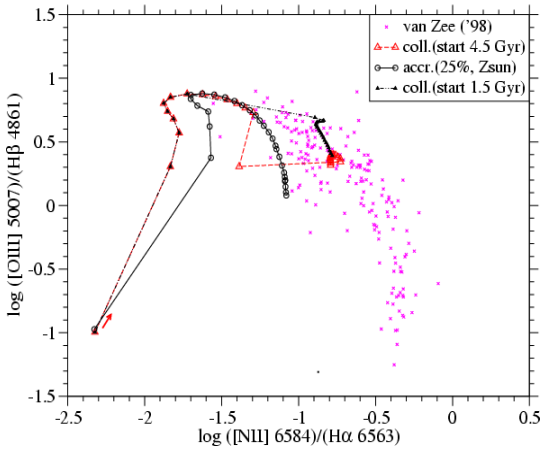




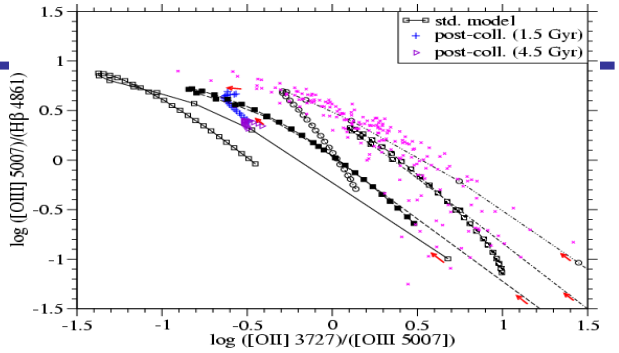
In this paper, we have completed the study by interfacing the galactic code with a photoionization code to compare the results with more approximate treatments of star formation and chemical history...

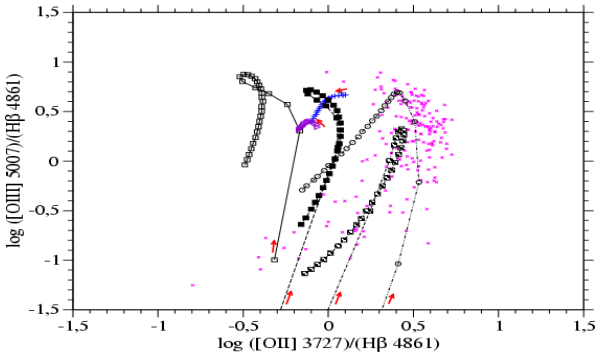


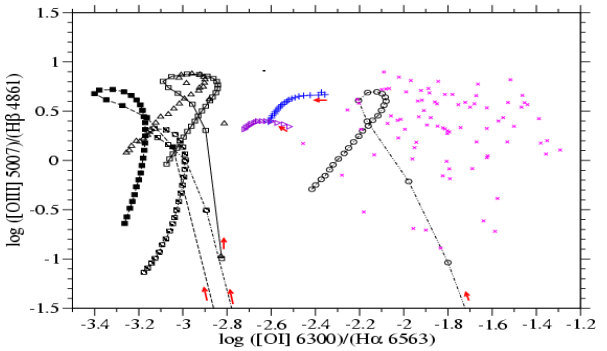




The agreement we show with the observational data thus argues that a coupled treatment is essential for predictions of the emission line diagnostics. This suggests that, if the metallicity history is self-consistently derived from the galactic evolution model, many of the details of the spectral energy distribution may not be needed to get a picture of the history of the gas.





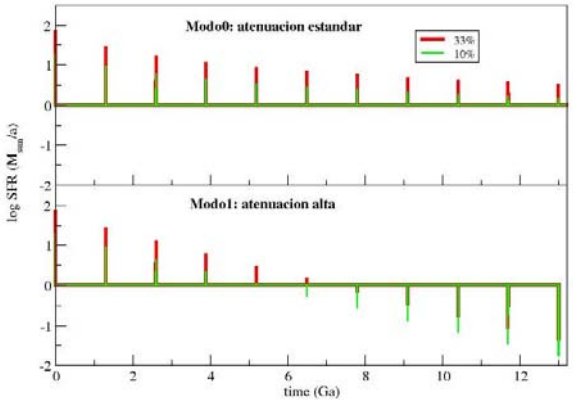


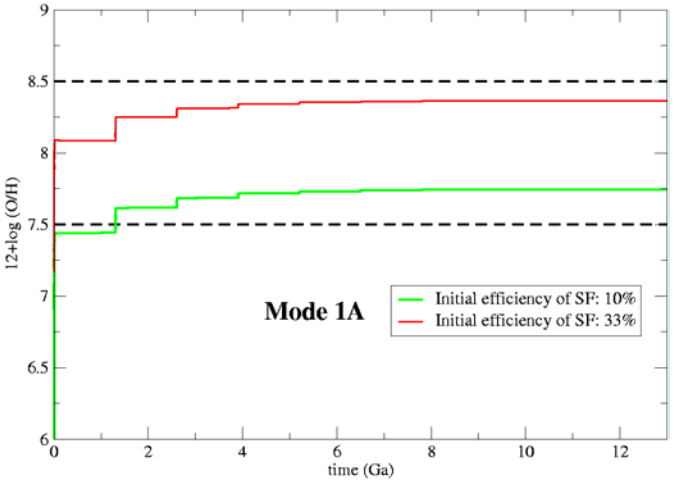
Chemical and Spectrophotometric Evolutionary Models for Emission Line Star-forming Galaxies

Martín-Manjón, Mollá, Díaz, Terlevich

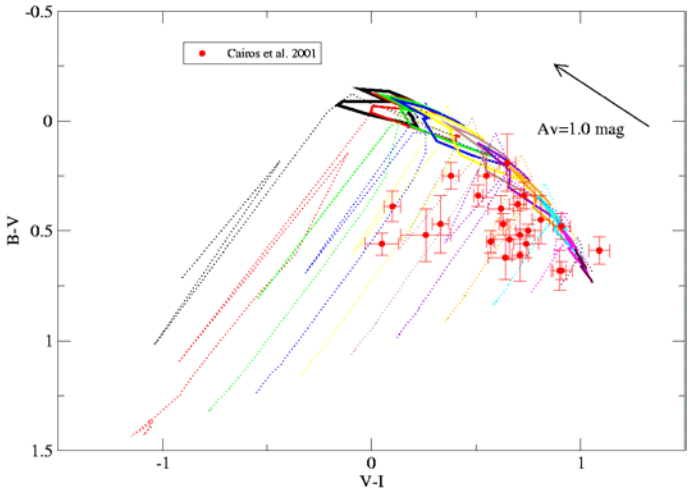
- **We have computed a series of realistic and self-consistent models of the emitted spectra of HII galaxies.**
- **Our models combine different codes:**

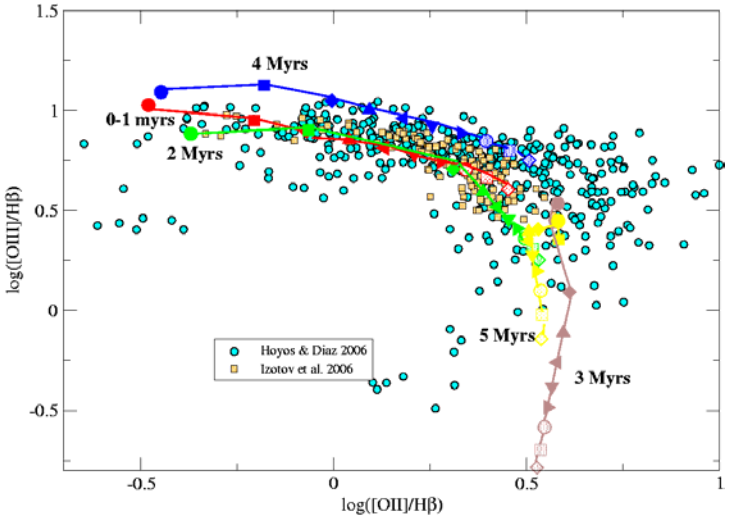
Chemical evolution model: Star formation history + age-metallicity relation (Ferrini et al.92,94)
+ Código de síntesis evolutiva: S.E.D población ionizante. (Mollá & García-Vargas,2000)
+ Código de fotoionización: líneas de emisión (CLOUDY)



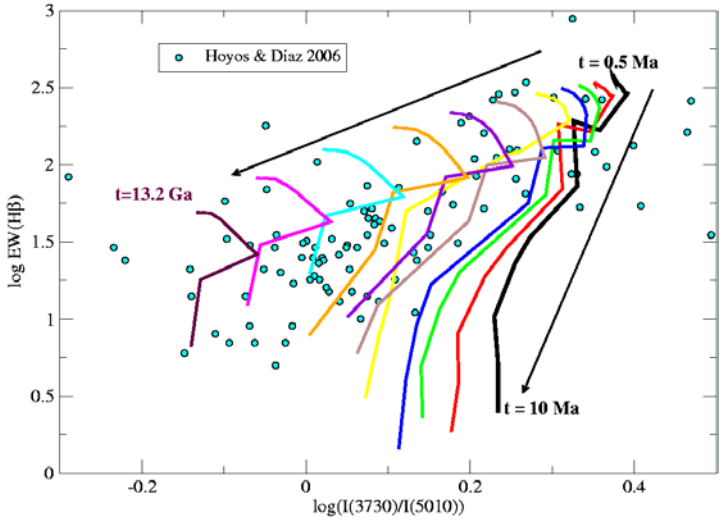


Results: EW(H_β) is not explained by a generacion of stars. It is need an old subjacent stellar population to reproduce consistently the photons number, colors and emission lines





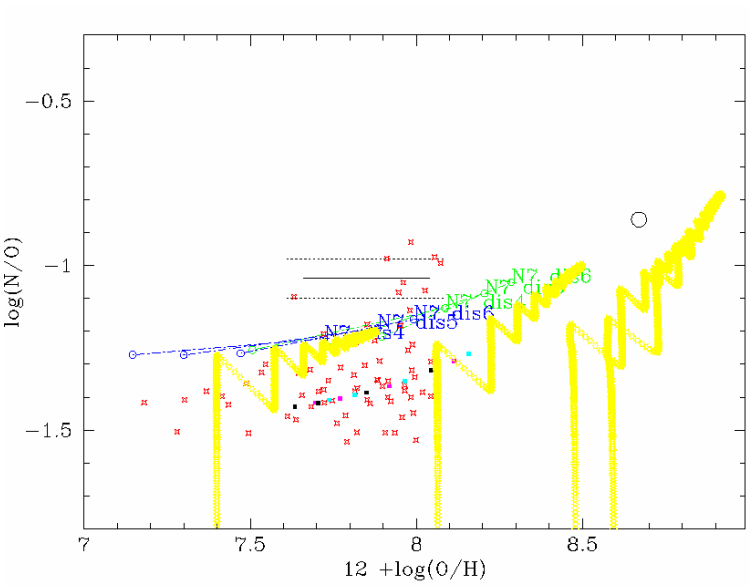
•The results of our code are compared with photometric and spectroscopic data of HII galaxies.
•Our technique reproduces observed diagnostic diagrams, abundances, equivalent width-colour and equivalent width-metallicity relations for local HII galaxies.
•The combination of parameters which characterize the current star formation on a time scale of Ma, and the SFH over a time scale of Ga, is found to provide an effective means to uncover the presence of underlying stellar populations.

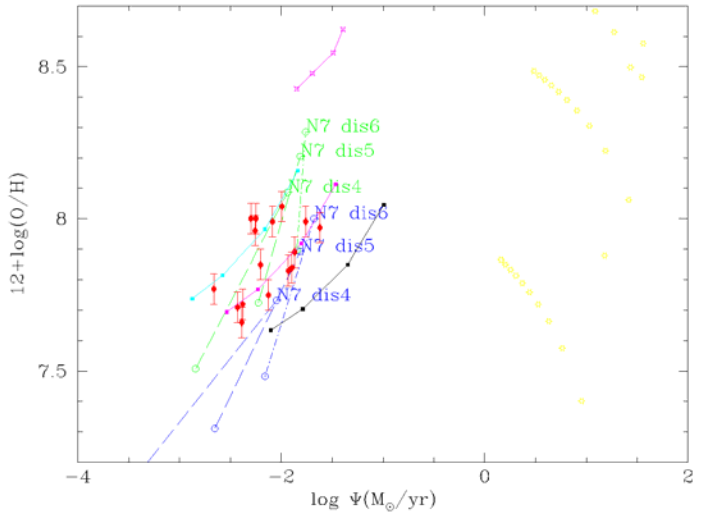


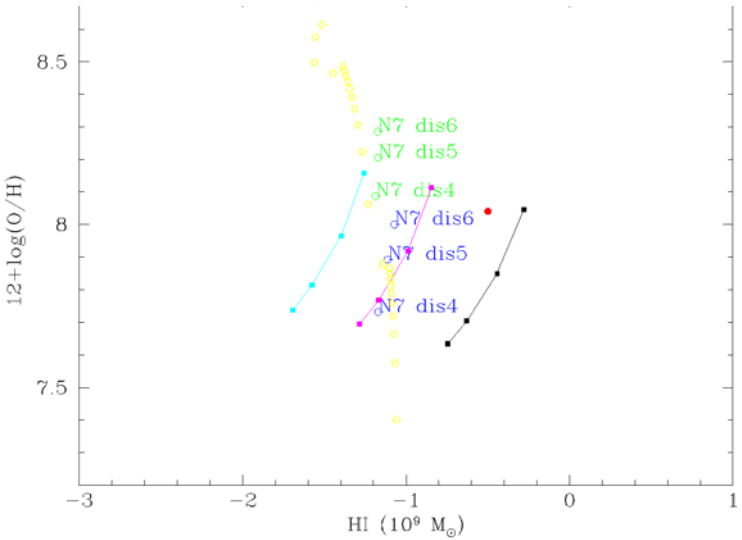
Data-Models comparison

Kehrig, Gavilán, Martín-Manjón, Mollá & Vílchez

Comparison of models for dwarf galaxias with continous star formation (cyan, magenta and black), for HII galaxies with star bursts (yellow), and models of the chemical evolution grid for the lowest mass and for the lowest star formation efficiencies (green and blue), with data (red points) obtained for IIZw70:





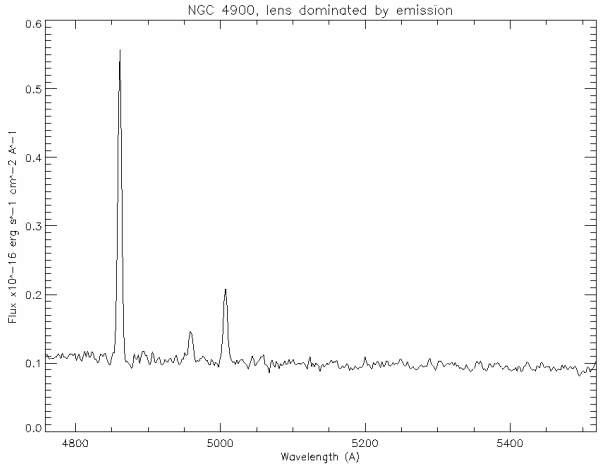


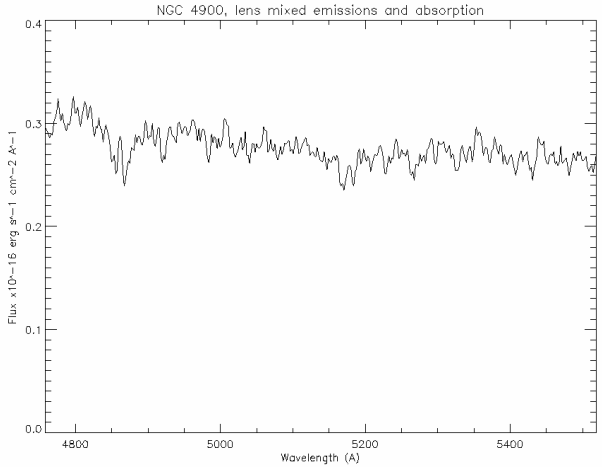
Stellar populations in Barred galaxies

Cantin, Robert, Mollá & Pellerin, 2007, in preparation

- **We have observed the centers of a sample of barred galaxies, using the integral field spectrometer OASIS, to study their stellar populations**
- **We find different structures within these regions defined by stellar populations of different ages and metallicities.**

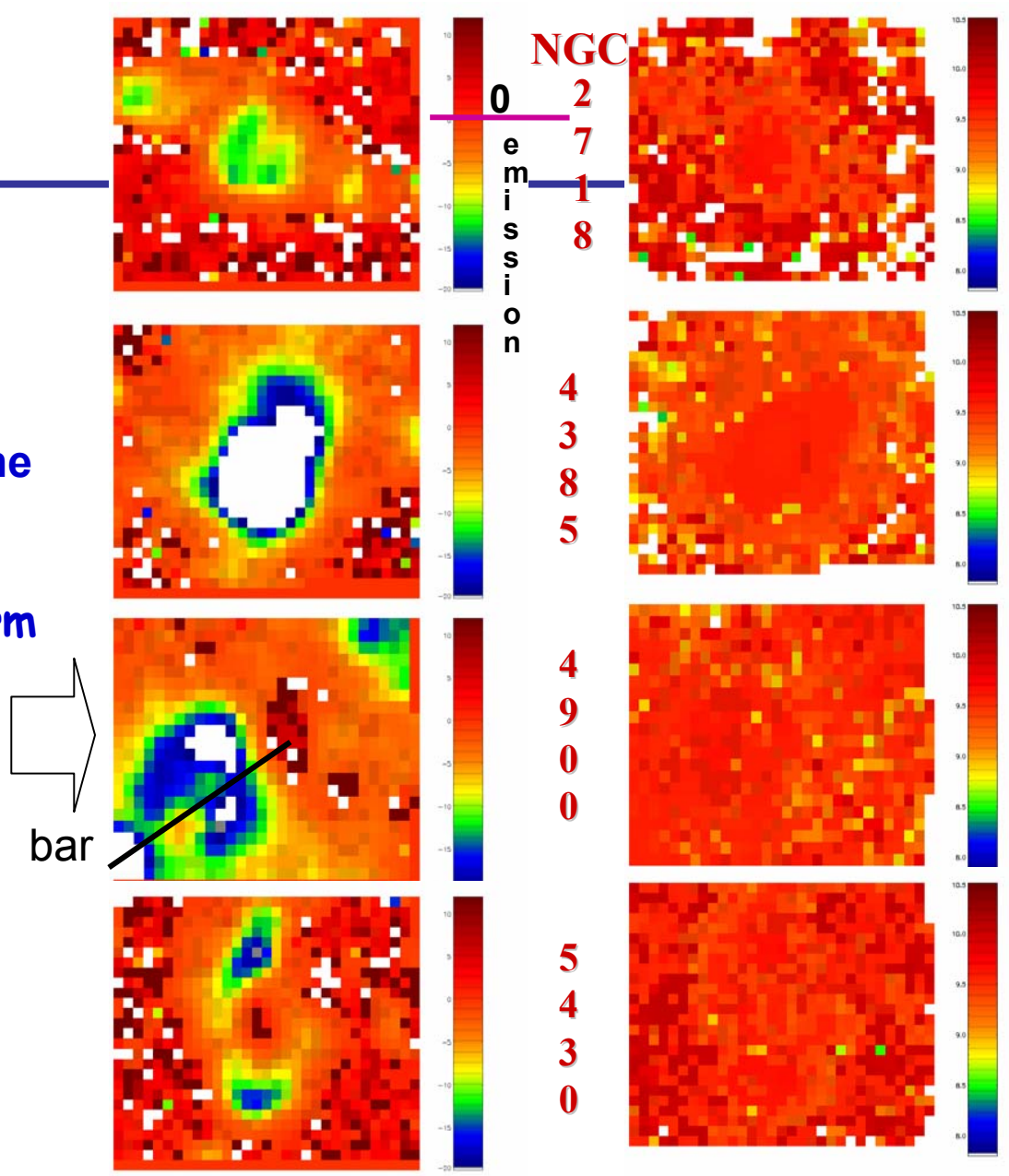
Datacube with ~800 spectra/galaxy





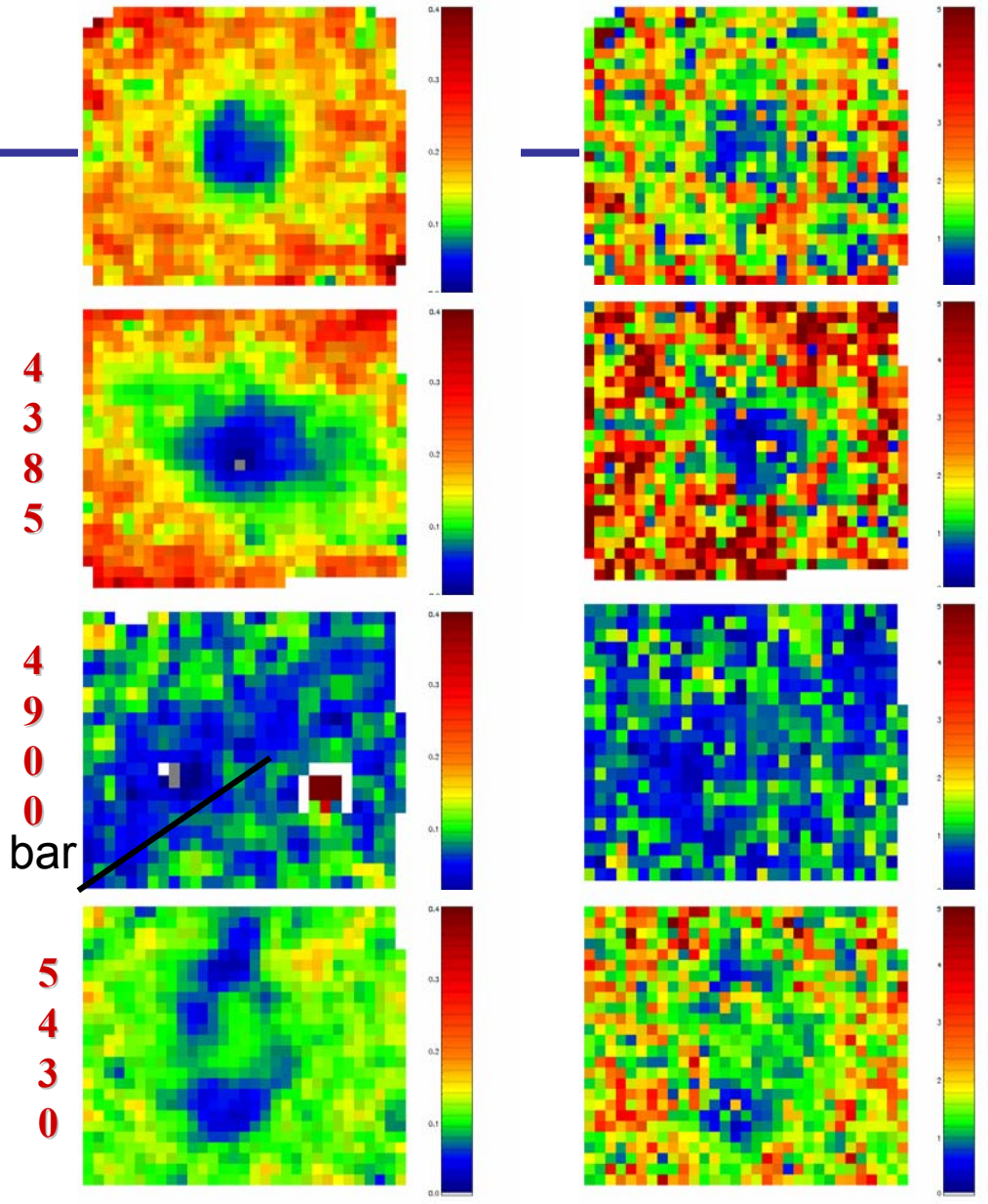
Young stellar populations

- Age variations: younger in the center
- Oxygen abundances ~ uniform



Old Stellar Populations

- Central regions with younger stellar populations





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