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M. Mollá / I. Márquez
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PREDICTED CHEMICAL EVOLUTION FOR SPIRAL DISKS FROM THEIR OBSERVED ROTATION CURVES

M. Mollá[1] and I. Márquez[2]

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The rotation curves for a sample of 67 spiral galaxies have been used as input for the multiphase chemical evolution model. By using N[II]/Halfa as estimator of the oxygen abundance, we constraint the possible models for each galaxy. We may, then, predict the time evolution of these galaxies and the present time radial distribution for gas, stars, and star formation rate surface densities and elemental abundances.

Introduction

Chemical evolution models are usually applied to our Galaxy, for which a large number of observations is available. These models may also be applied to other spiral galaxies (Mollá et al. 1996; 1999) for which observational data exist. They are very useful to determine the star formation history of the modeled galaxies.

We have applied the multiphase chemical evolution model (Ferrini et al. 1992) to our sample of 67 galaxies for which the rotation curve, have been measured (Márquez et al. 2002). In this paper we show results for 6 of these galaxies, but see Mollá & Márquez (in preparation) for details about the whole sample.

Computed Models

We use the cited measured rotation curves to calculate the total mass radial distribution in each galaxy with the classical equation: $M(R) = 2.3210^5 RV(R)^2$. These distributions, inputs of the multiphase chemical evolution models, are shown in Fig. 1 (first row) for 6 selected galaxies. This mass is assumed to be gas at the initial time which will infall into the equatorial plane and forms out the disk. The collapse time scale of this gas infall is defined by the total mass existing within each region.

Molecular clouds form from the diffuse gas and stars are formed from the cloud-cloud collisions. Both formation process rates are determined by the corresponding efficiencies or probability factors which depends on environmental effects. These efficiencies are free parameters and variable for each galaxy because they are not certainly known. Once computed the models, we obtain the radial distributions of abundances which must be compared with observational data in order to select the best one. The final values of efficiencies will be those for which the abundances are well reproduced.

The oxygen abundances are estimated by using the empirical relations given as a function of the parameter $N2 = \log(N[II]/H\alpha)$ by Van Zee et al. (1998), Raimann et al. (2000) and Denicoló et al.(2002), respectively:

$$
\begin{aligned}
12 + log(O/H) &= 9.36 + 1.02N2 \\
12 + log(O/H) &= 8.89\ (\pm 0.07) + 0.53(\pm 0.06)N2 \\
12 + log(O/H) &= 9.12\ (\pm 0.05) + 0.73(\pm 0.10)N2
\end{aligned}
$$

Results

The radial distributions of oxygen abundances which best reproduce the data are shown in the second row of Fig. 1 connecting the modeled regions, represented by ×, for our sample. The data are the filled symbols. [3]

Models fit very well the data for most of the galaxies, the radial trend being in agreement with the observations. It is clear that radial gradients are systematically steeper for the less massive galaxies and that inner regions usually show a flatter radial gradient than the observed for the whole disk.

Two correlations appear among the characteristic oxygen abundance of a galaxy and its radial gradient and the mass of the galaxy and/or the morphological type T. However, the correlations with the rotation velocity are stronger while the morphological type dependence appears as secondary.

Once obtained the model which is able to reproduce the data for each galaxy, we may consider the time evolution and the present time results given by this model as representative of each galaxy.

Thus, in Fig. 1, (third row) we represent the diffuse gas surface density radial distributions for the

[1]C.I.E.M.A.T., Madrid, Spain (mmolla@ciemat.es).
[2]Instituto de Astrofísica de Andalucía, Granada, Spain.

[3]Open dots of the same symbols are the values for which the uncertainty in Hα is large, which is considered when Hα < 10).

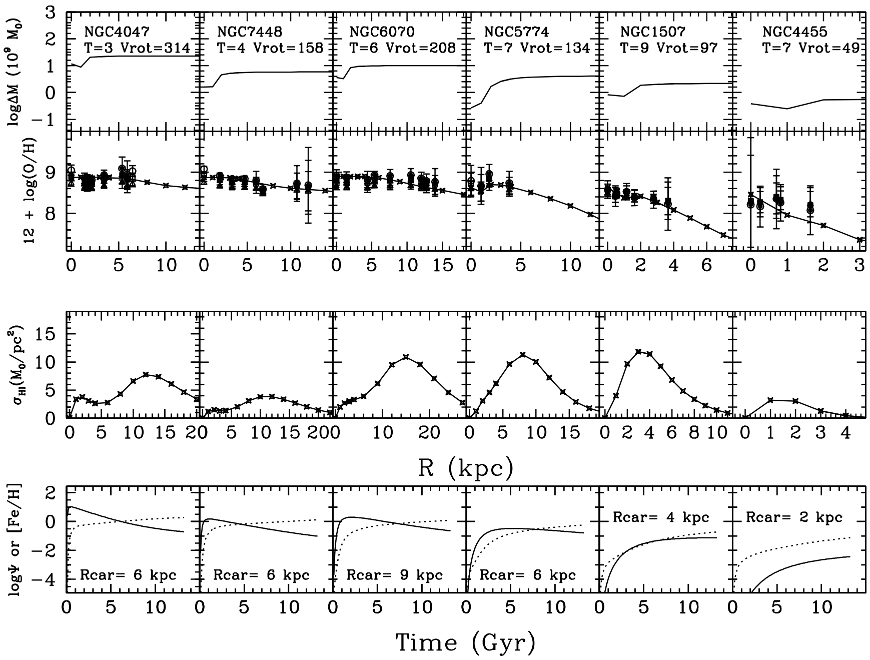

Fig. 1. Multiphase chemical evolution model results for 6 galaxies named at the top panel. From top to bottom: a) The total mass computed from the rotation curve b) The oxygen abundance $12 + log(O/H)$ in Data – VZEE (dots), RAI (triangles) and DEN (squares)– are shown as filled symbols. c) The predicted surface density of diffuse gas, $\sigma_{HI}(M_{\odot} pc^{-2})$ and d) The predicted star formation history and age-metallicity characteristic of each galaxy.

same galaxies, which we consider as model predictions. They show a maximum along the galactocentric radius. Larger the rotation velocity, larger the radius where it appears.

In the last row of Fig. 1, the predicted star formation history (solid line) and the age-metallicity relation (dotted line) are shown for a radial region given in each panel, characteristic of each galaxy and equivalent to the Solar Vicinity. The star formation is biased toward early times for the more massive galaxies, while it occurs later for the lowest mass and latest type ones

Conclusions

The chemical evolution models show to be a very useful tool to estimate, in a one to one basis, the actual evolutionary track of a spiral disk, allowing to estimate the star formation history and the age-metallicity relation.

The multiphase model may be easily applied to a large number of galaxies. This allows to perform statistical studies and the relation among the chemical features and on other galactic characteristics as the Hubble type or the total mass.

The most important conclusion is that the characteristic abundance of a spiral disk as its radial gradient of oxygen results to be clearly dependent on rotation velocity. This dependence is stronger than the corresponding one with the morphological type. This last correlation also exists (although shows a larger dispersion), probably as a consequence of other already known trend: the morphological type of spirals correlates with the rotation velocity having the less massive ones the latest morphological types.

The total mass, through its rotation velocity, appears, therefore, as the very conductor of the evolution in the spiral disks.

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