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CHEMICAL EVOLUTION OF LOCAL GROUP DWARF SPHEROIDAL GALAXIES

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RESUMEN

La evolución química de seis galaxias enanas esferoidales del Grupo Local es discutida sobre estudios realizados con un modelo de evolución química de una zona, el cual es capaz de reproducir las principales restricciones observacionales de estas galaxias. Varios cocientes de abundancias, la masa total, la masa de gas y la distribución de metalicidades predichos por esos modelos reproducen muy bien los datos observacionales. En nuestro escenario, la evolución de las dSphs está controlada principalmente por una tasa de formación estelar baja y por vientos galácticos muy intensos. La formación estelar baja origina la baja metalicidad observada, mientras los vientos galácticos intensos son responsables de la masa final de gas baja y del pronunciado decremento observado en los cocientes de abundancias. Además de esto, ambos parámetros ayudan a definir la forma de la distribución de metalicidades estelares, en acuerdo con las observaciones.

ABSTRACT

The chemical evolution of six local group dwarf spheroidal Galaxies is discussed based on studies performed with an one-zone chemical evolution model which is able to reproduce the main observational constraints of these galaxies. Several abundance ratios, the total mass, the gas mass and the metallicity distribution predicted by such models fit the observed data very well. In our scenario, the evolution of the dSphs is mainly controlled by a low star formation rate and by very intense galactic winds. The low star formation in these galaxies gives rise to the observed low metallicities, whereas the intense galactic winds are responsible for the low final gas mass and for the sharp decrease observed in the abundance ratios. Besides that, both parameters help in defining the shape of the stellar metallicity distributions, in agreement with observations.

Key Words: galaxies: dwarf — galaxies: local group — stars: abundances

1. GENERAL

The study of local group dwarf spheroidal (dSph) galaxies have considerably increased in the past few years and our knowledge of these system is developing fast, but certain key aspects regarding the formation and evolution of these galaxies remain unknown. The low values of [α/Fe], the particular patterns of neutron elements abundances, the lack of neutral gas in the central region of these galaxies, and other observational features are a still a matter of debate.

We analysed the evolution of six local dSph galaxies (Carina, Draco, Sextan, Sculptor, Sagittarius, and Ursa Minor) through the comparison of models predictions with the observed data by means of a detailed chemical evolution, which takes into account the contribution of low and intermediate mass-stars (LIMS) and supernovae (SNe) of both types (type II and type Ia) into the nucleosynthesis as well as their effect in the energetics of the interstellar medium (ISM). The successful results of such comparison allows us to draw a scenario to the evolution of these galaxies.

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2. THE MODEL

The models for the dSph galaxies are the same as described in Lanfranchi & Matteucci (2003, 2004), which allow one to follow in detail the evolution of the abundances of several chemical elements, starting from the matter reprocessed by stars and injected in the ISM through galactic winds and SNe explosions. The models adopt the basic equations given in Matteucci (1996) and Tinsley (1980) in order to describe the time-evolution of the abundance in mass fraction of an element i in the gas of the galaxy. In our models, the star formation history of each galaxy is given by the analysis of observed color-magnitude diagrams (see Lanfranchi & Matteucci 2007) and the SF is strongly affected by the occurrence of galactic winds, which remove a large fraction of the gas content of the galaxy, causing a sudden drop in the star formation rate (SFR).

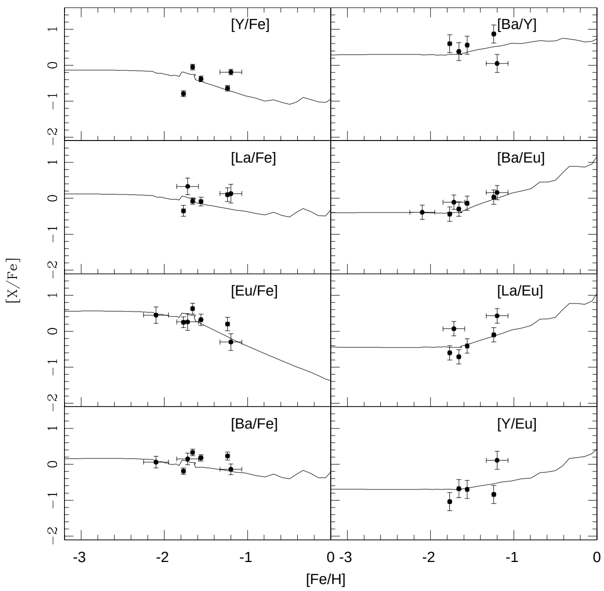

Fig. 1. The predicted evolution of neutron capture elements as a function of Fe for Sculptor compared to the observations.

2.1. *Results*

In Figure 1 we shown the abundance ratios of several neutron capture elements as a function of Fe predicted by the Sculptor model compared to the observations (Venn et al. 2004; Geisler et al. 2005). The adjust of the observations to model's predictions is very good, including, at high metallicities, the decline of [Y/Fe], [La/Fe], [Ba/Fe], and [Eu/Fe] and the increase of [Ba/Y], [Ba/Eu], [La/Eu], and [Y/Eu]. In both cases the change in the slope is a consequence of the intense galactic winds and its effect of the star formation rate. Soon after the winds starts a large fraction of the gas reservoir that fuels the SF is removed from the galaxy and, therefore, the SFR decreases substantially. With a very low SFR, the injection of elements produced by massive stars (Eu, La, small fractions of Y and Ba) is strongly reduced whereas the products of SNe Ia continue to enrich the ISM, causing the observed decrease. The increase in the heavy element ratios is a result of the same effects, since Ba and Y are also produced by LIMS, which have a longer lifetime than the massive stars responsible for the production of Eu.

In Figure 2 the comparison between the observed stellar metallicity distribution (Koch et al. 2006) with the prediction of Carina's model is shown. The position of the peak, the number of metal-poor stars

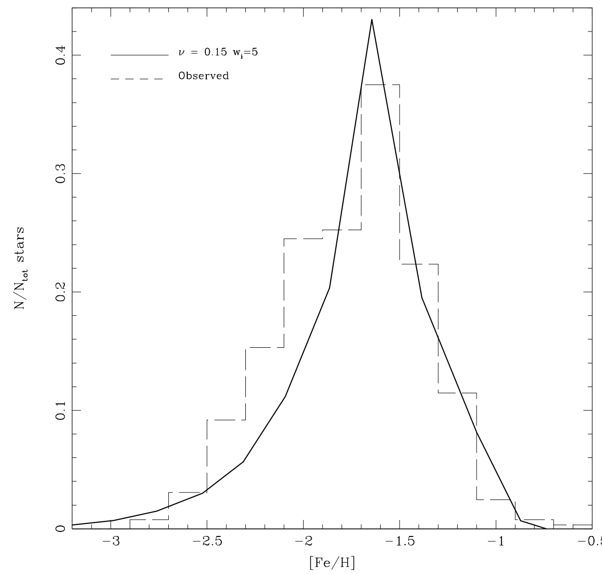

Fig. 2. The predicted stellar metallicity distribution of Carina's model compared to the observation.

and the decline at high metallicities are very well reproduced by the model, given strength to our scenario.

2.2. *Conclusions*

We adopted a detailed one-zone chemical evolution model to study a sample of six local dSph galaxies. By assuming that the SFR in these galaxies is very low (with a SF efficiency in the range $\nu = 0.005$–0.5 Gyr^{-1}, with the exception of Sagittarius $\nu = 3$ Gyr^{-1}) and that the galactic wind efficiency is very high ($w_i = 4 - 13$) we are able to reproduce very well several [α/Fe] ratios, the evolution of neutron capture elements as function of Fe, s- and r- process abundance ratios, the stellar metallicity distributions, and the gas mass observed in these galaxies.

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