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STUDYING OLD POPULATIONS WITH RR LYRAE VARIABLES IN THE LOCAL GROUP

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RESUMEN

Queremos estudiar las características y la extensión de la población vieja en un conjunto de galaxias en diferentes entornos en el Grupo Local, desde las galaxias enanas esferoidales satélites de M31, hasta las enanas irregulares aisladas, y hasta el propio halo de M31 y M33. Con este fin, pretendemos usar las estrellas variables de tipo RR Lyrae como trazadoras de la población vieja. Necesitamos un censo completo de estas estrellas en cada una de las galaxias de nuestro programa (o en cada campo observado en cada galaxia), y construir curvas de luz de gran calidad para cada una de ellas, para determinar la distribución de períodos y la fracción de variables RRab, RRc y RRd. Un importante subproducto de estas observaciones serán unos diagramas color–magnitud muy profundos que, en el caso de las galaxias enanas, van a cubrir la mayor parte de su extensión, y nos van a permitir estudiar la historia de la formación estelar de manera independiente.

ABSTRACT

We want to study the characteristics and the physical extent of the old populations in a sample of Local Group galaxies in different environments, from the dSph satellites in the halo of M31 to the isolated dIrr galaxies and to the haloes of M31 and M33 themselves. For this purpose, we plan to adopt RR Lyraes as stellar tracers. We need to obtain a complete census of these stars in the galaxies (or field of each galaxy) under study to construct high quality light-curves of the variable stars, to determine their distribution of periods, and the fraction of RRab, RRc, and multimode RRd variables. An important by-product of these observations will be very deep color–magnitude diagrams covering, in the case of the dwarf galaxies, most of each galaxy's field. This will provide an independent constraint on the star formation history of each galaxy.

Key Words: **GALAXIES: LOCAL GROUP — GALAXIES: STELLAR CONTENT — STARS: VARIABLES: RR LYRAE**

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1. INTRODUCTION

We are carrying out a program to characterize the old population in galaxies in different environments in the Local Group to answer the cosmologically relevant question of whether there is an epoch of initial star formation common to all types of galaxies. We know that all the Milky Way satellites have an old—globular cluster-age—population, and we know about bona fide old populations in some of the M31 satellites. But is this old population somehow related to the fact that these systems are immersed in a massive halo? As a matter of fact, theoretical predictions suggest that the first star formation episode in dwarf galaxies may have been delayed to $z \simeq 1$ owing to ionization by the UV background (e.g., Babul & Ferguson 1996). The nearby galaxies, and in particular those in the Local Group, are the perfect laboratory to assess on a quantitative basis the occurrence of a truly old population and therefore to test the prediction of these models.

The stellar tracers we plan to adopt are the RR Lyrae stars. These variables are valuable tools for both stellar population studies and as primary standard candles. Because among globular clusters they are found in those older than $\simeq 10$ Gyr, their presence in a stellar system traces unambiguously the existence of a bona fide old population. Moreover, and even more importantly, the pulsation characteristics of RR Lyrae stars—the topology of the instability strip, the period and amplitude distribution—

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(Bono et al. 1997, 2000) can be used to constrain the properties of the parent population (age, metallicity, horizontal-branch morphology). A quantitative estimate of these key parameters can supply tight constraints on the elusive characteristics of old populations in stellar systems whose turn-off region is too faint to be reached.

2. A PROJECT FOR THE GTC

Our goal is to characterize the RR Lyrae content of a sample of Local Group dSph and dIrr galaxies in a variety of environments, and some fields in the halo of M31 and M33, by constructing high quality light-curves of these variables. We want to determine their distribution of periods, and the fraction of RRab and RRc, and possibly multimode RRd. This will allow us to:

- Constrain the characteristics of the old population of these galaxies from the properties of their RR Lyrae population.
- Estimate their distance by three different methods; namely, the slope of the blue edge of RRc variables, the tip of the RGB, and the zero-age horizontal-branch luminosity.
- Trace the true extension of the old halo of these galaxies and the possible existence of tidal tails.
- Search for other types of variable stars such as classical or anomalous Cepheids.

In the case of the halo of M31 and its satellite system, direct comparison between the distribution of periods and the relative frequencies of RR Lyraes of different types will provide information to test whether the halo of M31 might have been formed from the assembly of tidally disrupted dwarfs similar to its own current satellites.

An important by-product of this program will be very deep CMDs, approaching the oldest main-sequence turn-offs ($S/N \simeq 8$ at $M_V = +3$) and covering, in the case of the dwarf galaxies, most of each galaxy's field. With these, it will be possible to:

- Determine the star formation history independently using color–magnitude diagram modeling techniques (Gallart et al. 1999) and map its changes with position in the galaxy.
- Provide independent estimates of the mean metallicity and its spread using the RGB bump and the slope of the RGB.

The GTC is necessary for this project because of the faintness of the targets to be observed and the limited amount of time that each observation may span in order to avoid smearing of the light-curves: RR Lyraes have $M_V \simeq +0.7$ and $M_B \simeq +1.0$. Since, beyond the Milky Way halo, Local Group galaxies span a range in distance modulus of $(m-M)_0 = 24.5$ to 26, we need to reach $V = 25.2$, $B = 25.2$ (and fainter), with $S/N \simeq 20$ with exposure times less than $\simeq$1800 s, to avoid smearing of the light-curves. To attain this goal, 2500 s with $0''.6$ seeing would be needed with a 4 m telescope for the closest systems, while 700 s would be enough with the GTC.

In addition, OSIRIS' wide field ($8'.53 \times 8'.53$) will allow us to cover the main body of any of the program galaxies in a single field, and to sample the halo and search for extratidal extensions in a couple more strategically placed fields.

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