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NGC 6822: detection of variable stars with ISIS2.1

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Abstract. Preliminary results on the detection of a conspicuous number of variable stars in the dwarf irregular galaxy NGC 6822 are presented. We stress the need for packages specifically designed to the research of variables in distant galaxies and/or when data are affected by a high level of crowding.

Key words. Galaxies: individual (NGC 6822) – Local Group

1. Introduction

Variability involves many phases of stellar evolution: variable stars are both tracers of stellar populations and tests for stellar evolution theories.
As a part of the ongoing program on the study of variable stars in Local Group Galaxies carried out at the Bologna and Padua Observatories, we are studying the dwarf irregular galaxy NGC 6822. We obtained time series observations (36 V and 11 B 15-min exposures for a total of 15 hours, spread on 3 nights) with the Very Large Telescope (VLT, Paranal-Chile) in August 2001.
Traditionally the detection of variable stars is performed with the scatter diagram, which plots the mean magnitude of each star in the field and its standard deviation. Candidate variables are picked up from this diagram and as stars whose standard deviation is larger than 3σ, (where σ is the rms of "bona-fide" constant stars at the same magnitude level.) Usually structures like fingers, corresponding to the region of classes of variables of constant mean magnitude, are seen in the scatter diagram, as the RR Lyrae finger and the Cepheid finger. This method works very well in globular clusters and nearby fields, while does not work in distant galaxies or very crowded areas, like our NGC 6822 field. In very crowded conditions the scatter diagram is dominated by photometric errors, the typical structures are not visible and the efficiency of the detection rate decreases dramatically.

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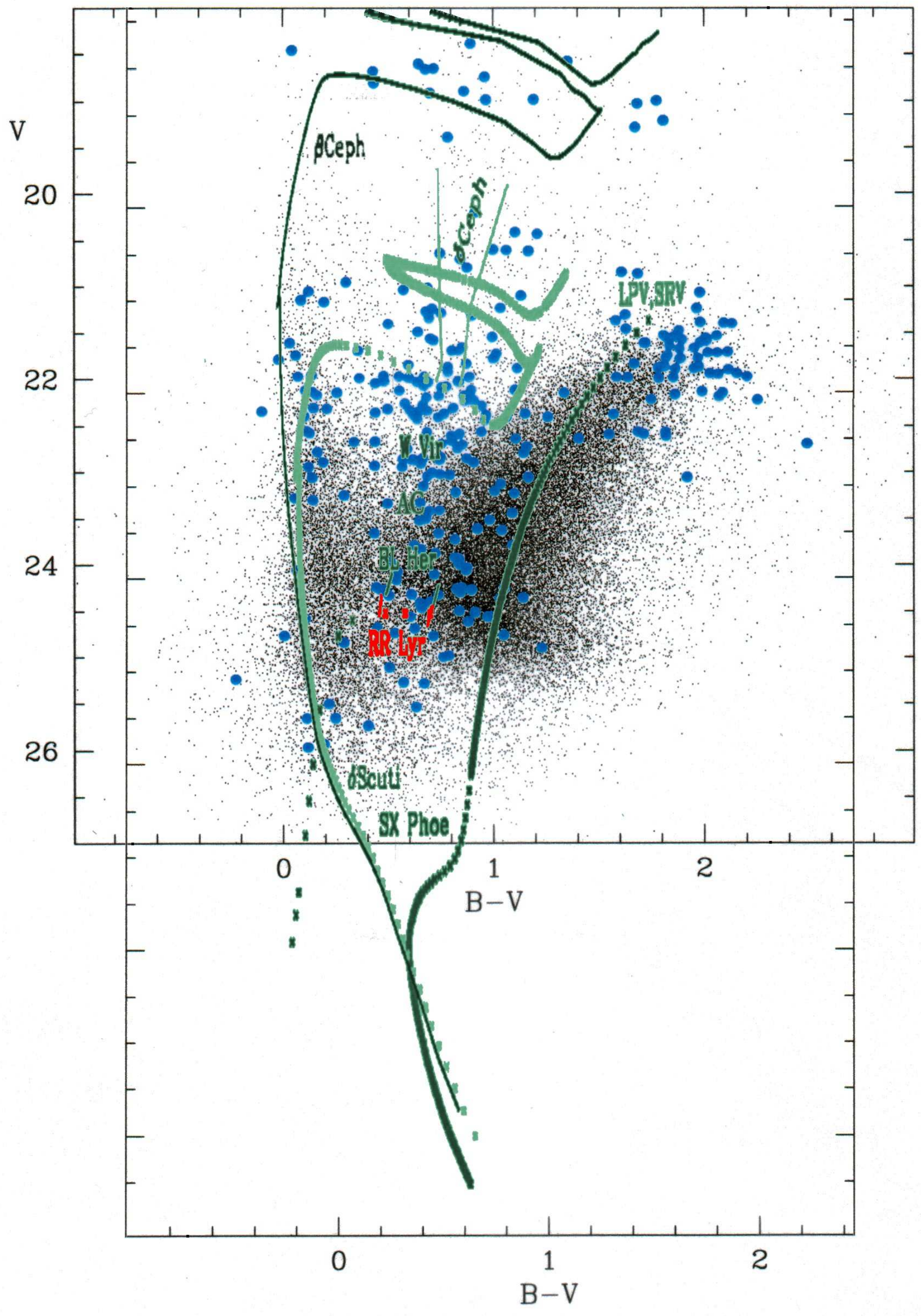

Fig. 1. Color magnitude diagram of NGC 6822. Big circles (blue in the electronic version of the paper) mark candidate variable stars detected by ISIS2.1. Superimposed (in green) are the theoretical loci of the different types of variable stars. A reddening E(B − V) = 0.25 mag was assumed according to Schlegel et al. (1998).

2. ISIS2.1 and data reduction.

ISIS2.1 (Alard 2000) is a package specifically designed for the detection of variable stars in crowded fields. It is based on an optimal image subtraction technique: in the subtraction of two images of the same field all constant stars will cancel out and only variables will remain. Two basic conditions must be satisfied to optimize the subtraction: the images must be geometrically and the physically aligned. The former condition requires that all images have the same coordinate system; the latter condition requires that all images have the same seeing condition and exposure time.

ISIS2.1 is designed to achieve all these requirements before going on with the subtraction of the images. The procedure consists in the following steps: (1)geometric alignment of the image series and remapping of the images in the same grid; (2)construction of the reference image obtained by stacking a suitable subset of images, and convolution of the reference image with a kernel to adjust for seeing variations and geometrical distortions of individual frames; (3)subtraction of each individual frame from the convolved reference image; (4)photometry of the variable objects on the difference images, in terms of differential fluxes. Light curves in a magnitude scale are then obtained through the photometric reduction of the reference image. Reduction of the reference image was performed using DAOPHOT and ALLFRAME (Stetson 1994).

ISIS2.1 improves the variable stars search in two different ways, with respect to the traditional techniques: increases the efficiency of the detection rate, and improves the quality of the light curves. Each of these two points will be analyzed in detail in the next paragraphs.

3. Efficiency of the detection rate.

ISIS2.1 detected 450 candidate variables in NGC 6822. So far we have studied a subsample of about 100 of them (all candidate variables with v$\leq$ 13.5 mag and a ten of brighter ones). About 90% of them turned out to be real variable stars, they are mainly RR Lyrae stars and Anomalous Cepheids. Less than 15% of them would have been detected with a traditional technique, since most of the real variables were found to lie in regions of the scatter diagram dominated by photometric errors.

Figure 1 shows the color magnitude diagram of NGC 6822, candidate variable objects are marked by big circles, solid lines are the theoretical loci occupied by different types of variables. The figure was obtained superimposing the theoretical tracks to NGC 6822 color magnitude diagram and shifting the x-axis to account for the redding effect ($E(B-V) = 0.25$ mag according to Schlegel et al. 1998). All regions where theory predicts the presence of variables are well populated. The instability strip from Classical Cepheids to the RR Lyrae region can be clearly seen. Many variables are found also at the tip of the Red Giant Branch where are expected to lie long period variables ($P \geq 50$ days), like Mira's and Semiregulars. Similar results were found by Bersier & Wood (2002) in Fornax. They concluded that some of these stars are long period variables, while others are giants that vary with short periods and small amplitudes because of instabilities in their external layers. Some variables are also found on the main sequence of NGC 6822: they could be eclipsing binary systems or stars that pulsate on the main sequence, like β Cephei stars. Study of the complete sample of candidate variables is in progress.

4. Quality of light curves.

Figure 2 shows the light curves for two of our variables. Light curves on the left panel were obtained with Daophot, those on the right panel are from ISIS2.1. The good quality of light curves allowed us the discovery of Anomalous Cepheids with very small amplitude ($0.1 \div 0.3$ mag). These variables would have never been recognized be-

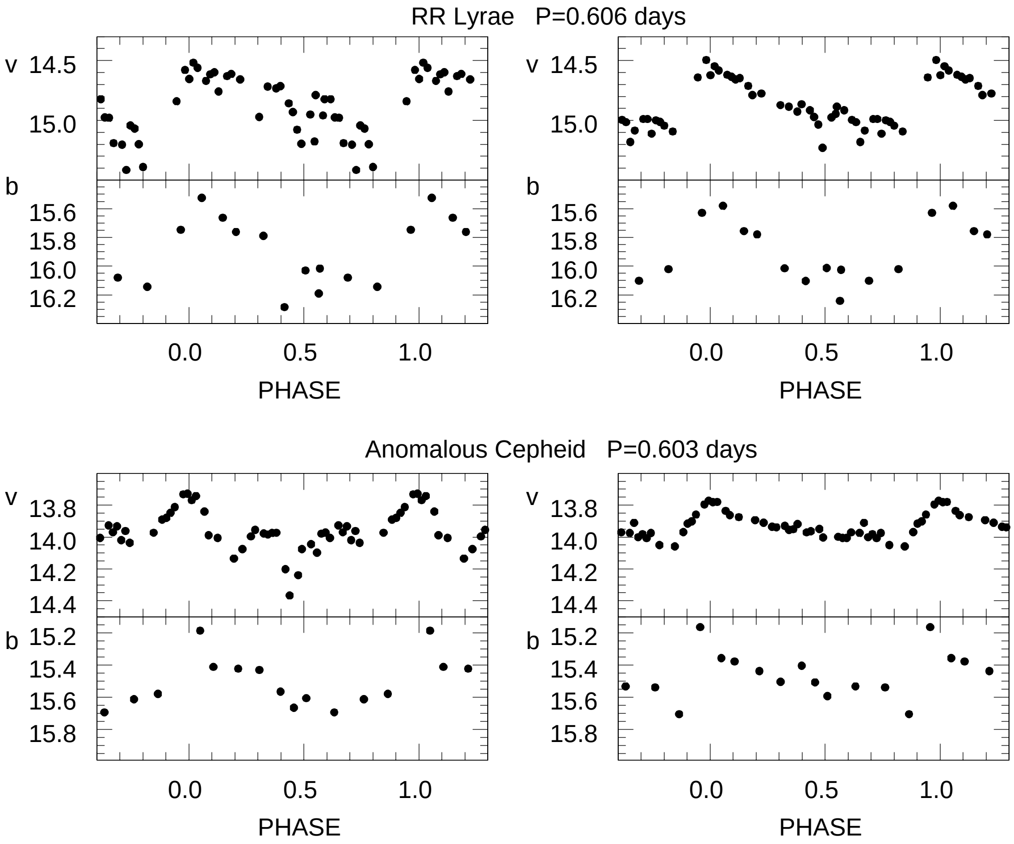

Fig. 2. Light curves of an Anomalous Cepheid and an RR Lyrae star of NGC 6822. Left panels: light curves obtained with Daophot. right panels: light curves obtained with ISIS2.1.

cause of the very scatter of their traditional Daophot photometry.

5. Conclusions.

The really good performances of ISIS2.1 allowed us the detection for the first time of RR Lyrae stars and small amplitude Anomalous Cepheids in NGC 6822. RR Lyrae stars mark the Horizontal Branch level (otherwise not visible on the color magnitude diagram). The presence of the Horizontal Branch demonstrates without any doubt that NGC 6822 started forming stars on an early epoch: t $\geq$ 10 Gyr ago, at least.

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