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The WeCAPP variable star catalogue of M31

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Abstract. We present the WeCAPP catalogue of variable stars found in the bulge of M31 (Fliri et al. 2005). Observations in the WeCAPP microlensing survey (optical *R* and *I* bands) for a period of three years (2000-2003) resulted in a database with an excellent time coverage. We detected 23781 variable sources in a $16.1' \times 16.6'$ field centered on the nucleus of M31. The catalogue of variable stars gives the positions, the periods, and the variation amplitudes in the *R* and *I* bands. We classified the variables according to their position in the *R*-band period-amplitude plane. Three groups can be distinguished; while the first two groups can be mainly associated with Cepheid-like variables (population I Cepheids in group I; type II Cepheids and RV Tauri stars in group II), the third one consists of Long Period Variables (LPVs). We detected 37 RV Tauri stars and 11 RV Tauri candidates, which makes this catalogue one of the largest collections of this class of stars to date. The classification scheme is supported by Fourier decomposition of the light curves. Our data shows a correlation of the low-order Fourier coefficients Φ_{21} with Φ_{31} for classical Cepheids, as well as for type II Cepheids and RV Tauri stars.

Key words. Galaxies: individual: M 31 – Stars: variables : general - Stars: variables: Cepheids - Stars: Population II

1. The Variable Sources

To extract variable sources from the data taken simultaneously with the 0.8m telescope at Wendelstein (Bavaria, Germany) and with the 1.2 m telescope at Calar Alto (Spain) we implemented a difference imaging technique. This allowed us to detect variable source at the theoretical Poisson noise limit even in highly crowded fields like the central part of M31 (Riffeser et al. 2001, 2003). We used the χ^2_ν deviation of the light curves relative to a constant baseline fit to detect the variable sources in the difference images. Periods of the variable sources were determined by applying the Lomb-Scargle algorithm to the *R*- and *I*-band data separately, yielding at the same time periods and their statistical significance. Periods were classified as real if the determinations in both bands agreed in close boundaries and one of them showed an acceptable significance. Otherwise the light curves were inspected visually to decide whether one of the periods is real or if the variation is of more irregular nature. The position of the variables on the *R*-band period-variation amplitude plane revealed the presence of three groups (Fig. 1). Group I contains 29 classical Cepheids pulsating in the fundamental mode, 2 s-Cepheids, one Cepheid

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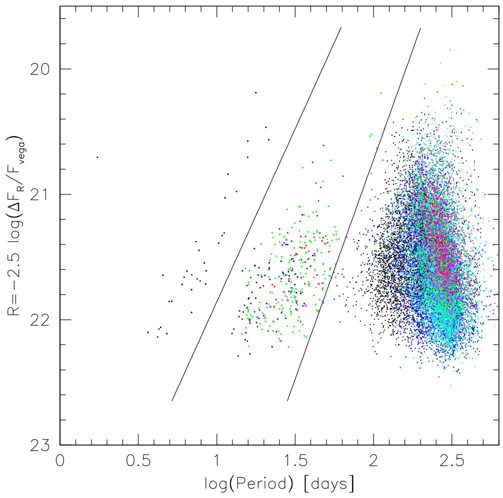

Fig. 1. Period-amplitude relation in the R-band for the catalogue sources. Three populations are visible in this diagram. The black lines show the defining relations (from left to right) for group I (population I Cepheids: black dots), group II (type II Cepheids: blue dots; RV Tauri stars: red dots; RV Tauri candidates: open magenta circles; SR variables: green dots), and group III (LPVs). The sources in group III are color-coded according to the significance of the I-band period as returned by the Lomb algorithm (low significance: black → blue → red: high significance). Note, that the magnitudes in this diagram are not the real variation magnitudes of the sources.

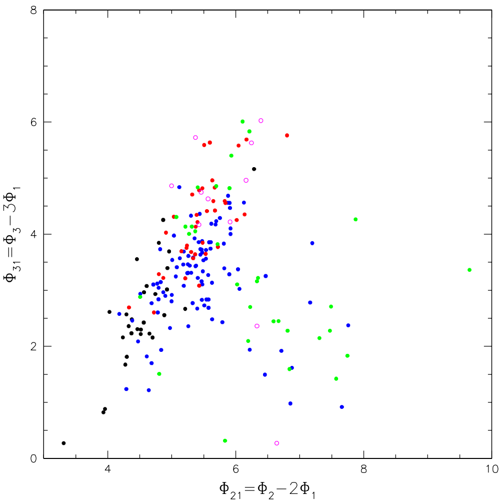

Fig. 2. Phase differences $\Phi_{ij} = \Phi_i - i\,\Phi_j$ as determined from the R-band data plotted against each other. Black dots: population I Cepheids (group I); blue dots: type II Cepheids (group II); red dots: RV Tauri stars (group II); open magenta circles: RV Tauri candidates (group II). As green dots, we show the LMC type II Cepheids and RV Tauri stars from Alcock et al. (1998), which fall on the sequences of the WeCAPP sources. For the RV Tauri stars, we use the formal period in the analysis.

of intermediate type, and one beat Cepheid candidate. One further group I source, which remains unclassified in the catalogue, shows two periods. Group II comprises 93 type II Cepheids, 37 RV Tauri stars, 11 RV Tauri candidates, and 193 low period semi-regular variables. Group III consists of 4287 irregular and 18974 regular/semi-regular variables. 82 presumably group III members show variations on longer timescales than the survey length. The positions on the R-band period-amplitude plane of the 31 eclipsing binary candidates coincide with the positions of groups I and II. Finally we detected 39 miscellaneous variables, among them 16 novae and 15 R Coronae Borealis candidates.

2. Fourier parameters

We fitted truncated Fourier series of the form $C + A_0 \Sigma_{i=1}^{N} A_i \cos(i\omega(t - t_0) + \Phi_i)$ to the light curves of groups I and II and determined the amplitude ratios and phase differences between the different harmonics. The classical Cepheids show a clear correlation of the phase differences, but also for the type II Cepheids and the RV Tauri stars both phase differences are correlated (Fig. 2). The sequences of RV Tauri stars and type II Cepheids overlap, making the RV Tauri sequence into an extension of the Cepheid II sequence. This favors the close connection between these two types of stars.

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