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Memorie della

The Araucaria Project

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Abstract. Results from a long-term observational project called the Araucaria Project are presented. Based on Wide Field optical monitoring of 8 nearby galaxies, covering a large range of metallicities, more than 500 Cepheids and a few hundred Blue Supergiant candidates were identified. From the analysis of Cepheid P-L relations of outstanding quality derived from our data we conclude that the slope of these relations in the I band and Wesenheit index are not dependent on metallicity. Comparing the I-band magnitudes of Cepheids of a period of ten days, as computed from our P-L relations, to the I-band magnitudes of the tip of the RGB, which is widely believed to be independent of population effects, we cannot see any obvious dependence of the zero point of the I-band P-L relation on metallicity. A preliminary analysis of IR follow-up observations of sub-samples of the identified Cepheids in various galaxies of the project show that the distances obtained from these data are systematically shorter by about of 0.1 mag than those derived from the optical photometry. It is likely that this effect can be attributed to the internal reddening in the program galaxies. The selected Blue Supergiant candidates were observed spectroscopically with 8m-class telescopes to determine their element abundances, and their luminosities from the Flux-weighted Gravity-Luminosity Relationship. Results on this aspect of the Araucaria Project are presented in the review of Kudritzki presented during this conference.

Key words. distance scale: – galaxies: galaxies and redshifts – galaxies: stellar content – stars: Cepheids

1. Introduction

The Araucaria Project was started some four years ago at the University of Concepción (Gieren et al. 2001), with the main goal to study how population effects such as age and/or metallicity can affect the distance determination with the main stellar distance indicators. In the course of the Araucaria Project we are mainly interested in Cepheids, Blue Supergiants, TRGB, red clump stars, and RR Lyrae stars. Eleven galaxies, each one containing most of the mentioned "standard candles" and having widely different environments were selected, and then observed with a variety of telescopes and instruments. The observations have resulted in a huge database of very accurate measurements, very well suited for calibrating the dependence of the brightness of the studied distance indicators on environmental properties, and therefore improving the whole distance scale in the Universe. Some preliminary results from Araucaria were presented by Pietrzyński and Gieren (2003). In this invited

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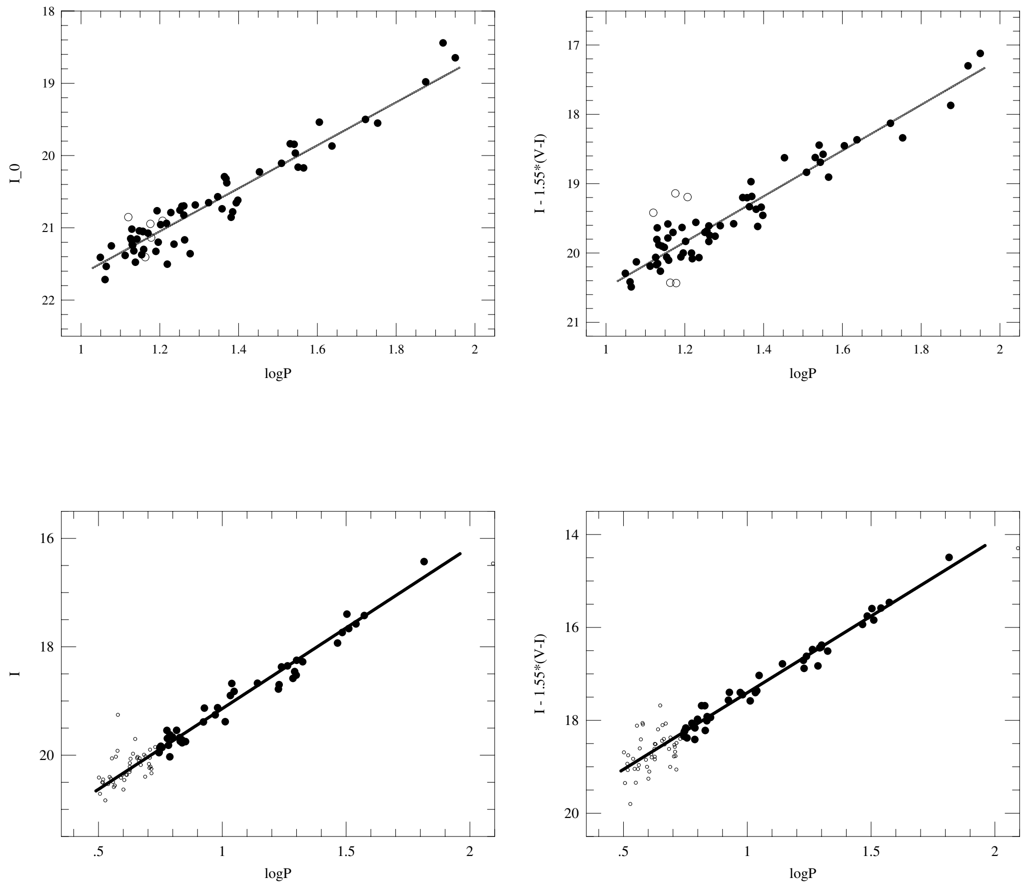

Fig. 1. Exemplary P-L relations in I and Wi bands for Cepheids in NGC 300 (upper panels), and NGC 6822 (lower panels).

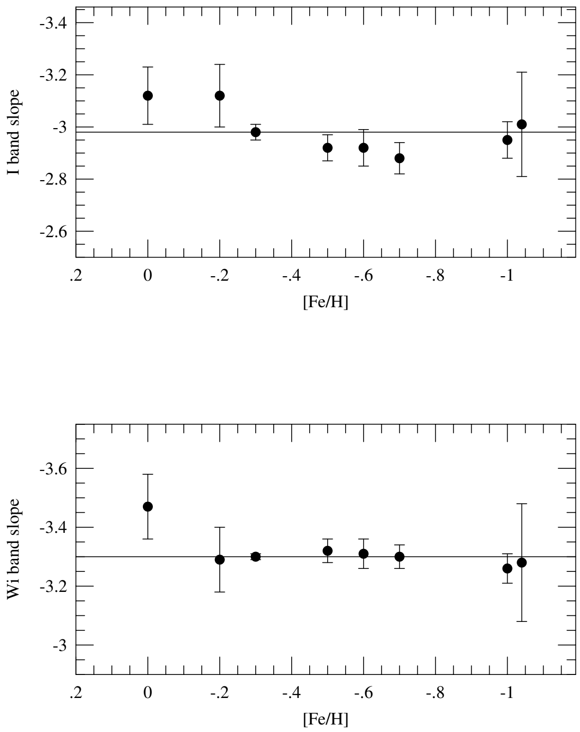

Fig. 2. Slope of the P-L relations in I and Wi bands versus metallicity for Cepheids in nearby galaxies. No dependence of the slopes in both bands on metallicity, over a broad range of metallicities, is indicated by these data.

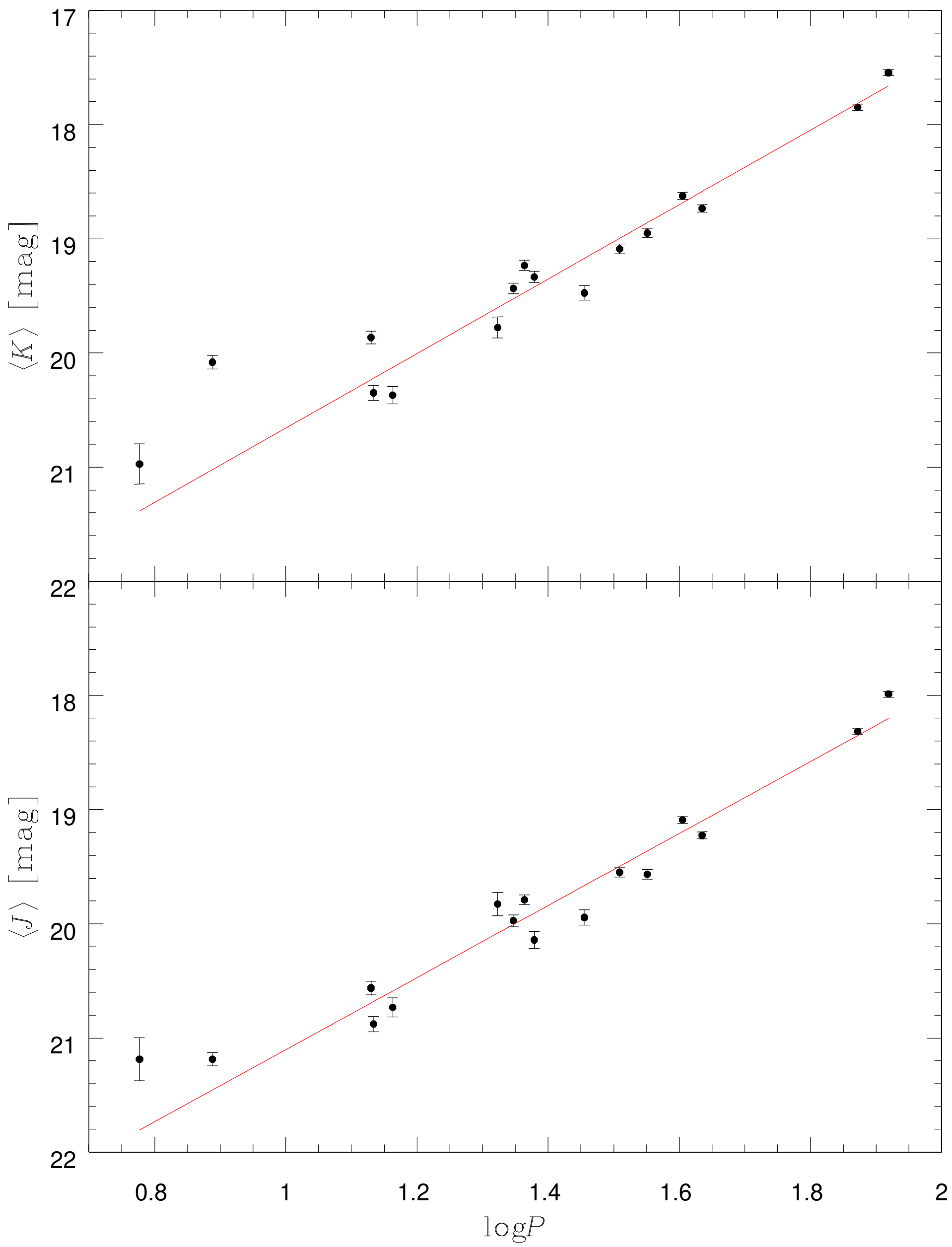

Fig. 3. P-L relation in the J band (lower panel), and K band (upper panel) for Cepheids in NGC 300.

talk, we will discuss some more recent results which focus on the usefulness of Cepheid variables as distance indicators.

2. Observations

The first necessary step which needed to be carried out was an extensive multi-epoch Wide Field optical survey for distance indicators in our target galaxies. For this purpose, we used the 1.3-m Warsaw telescope at the LCO, the 2.2-m MPI telescope at La Silla, and the 4-m Blanco telescope at the CTIO. All of these telescopes are equipped with Wide Field imagers (8k x 8k mosaics) having large fields of view (about 35 x 35 arcmin), combined with a very good spatial resolution, allowing us to observe the whole galaxy in one shot. The observations were typically conducted over 1-2 years through V and I band filters. Between 60 and 200 V and I band images were collected for each program galaxy.

These data were very useful for selecting fields rich in Cepheids and Blue Supergiants for the follow-up IR and spectroscopic observations obtained with the ESO VLT telescopes located at Cerro Paranal, and the Magellan telescopes at LCO.

3. Results

3.1. Optical survey

In Table 1 we summarize the results for the Cepheid surveys in our target galaxies. The columns contain the names of the observed galaxies, the number of discovered Cepheids, the number of observed epochs, the range of Cepheid periods found, and the current status of the observational campaign (on-going or finished).

The Cepheid P-L relations in the I band and the Wesenheit (Wi) index for NGC 6822 and NGC 300 are shown in Fig. 1. In Figure 2, the slopes of the P-L relations in I and Wi are plotted versus metallicity for the LMC, SMC, IC 1613 (Udalski et al. 1999, Udalski et al. 2001), Milky Way (Gieren et al. 2005b), NGC 300 (Gieren et al 2004), NGC 6822 (Pietrzynski et al. 2004), NGC 3109 and WLM (Pietrzynski et al. in preparation). As one can see, the slopes of the P-L relations in both bands do not depend on metallicity, within the sensitivity of our current measurements. While a careful study of the possible dependence of the zero points of the Cepheid P-L relations on metallicity must await the final analysis of all our data, our preliminary results indicate that the effect is very small, if at all present (Pietrzynski et al. 2004). The catalogs of Cepheids together with the distance determinations for NGC 300 and NGC 6822 based on the optical data were already reported (Pietrzyński et al. 2002, Pietrzyński et al. 2004, Gieren et al. 2005). The papers with the corresponding results for the other galaxies of the Araucaria Project will follow soon.

3.2. Infrared follow-up

There are several important advantages of using infrared observations in studying Cepheids. The most important one is that the extinction in K band is about an order of magnitude smaller as compared to the V band. Moreover, the slope of the P-L relation in the infrared is steeper than in the optical, and accurate mean magnitudes of Cepheids in JHK bands can be derived from just one observation (Soszynski, Gieren and Pietrzynski 2005). Typical infrared P-L relations obtained for Cepheids in our galaxies are shown in Fig. 3. The slopes of the P-L relation in J and K bands in NGC 300 and IC 1613 were found to be almost identical to those for LMC Cepheids (Persson et al. 2004). Having at hand distance moduli derived in optical and infrared bands, it is possible to derive accurate reddenings, and thus an improved distance. In two of the galaxies for which we finished the analysis of our IR data (NGC 300 (Gieren et al. 2005a), and IC 1613 (Pietrzynski et al. in preparation)), we obtained reddenings being significantly larger than the foreground reddening in the directions to these galaxies (0.1 mag vs 0.02 mag).This suggests that the internal reddening plays a very important role in distance determinations with Cepheids in optical bands, and that IR follow-up observations are a ”must” to determine accurate true distance moduli, properly corrected for the effects of dust absorption internal to the host galaxies.

Table 1. Results from the optical survey

Galaxy	N of Cepheids	N of observations	period range	status
NGC 300	129	80	115 - 5	finished
NGC 6822	116	77	124 - 1.7	finished
WLM	30	150	54 - 3.5	finished
NGC 3109	90	85	40 - 3.5	finished
Phoenix	0	50	—-	finished
NGC 55	80	70	121 - 6	finished
NGC 247	50	84	114 - 11	on-going
NGC 7793	–	60	—-	on-going

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References

Gieren, W., Pietrzynski, G., Walker, A., Bresolin, F., Minniti, D., Kudritzki, R.P., Udalski, A., Soszynski, I., Fouqué, P., Storm, J., Bono, G. 2004 AJ, 128, 1167

Gieren, W., Pietrzynski, G., Soszynski, I., Bresolin, F., Kudritzki, R.P., Minniti, D., Storm, J., 2005a, ApJ, 628, 695

Gieren, W., Storm, J., Barnes, T.G.III, Fouqué, P, Pietrzynski, G., Kienzle, F., 2005b, ApJ, 627, 224

Persson, S.E., Madore, B.F., Krzeminski, W., Freedman, W.L., Roth, M., Murphy, D.C., AJ, 2004, 128, 3339

Pietrzynski, G., and Gieren, W., 2003, IAU Colloqium 193 ASP Conference Proceedings vol 310, 87

Pietrzynski, G., Gieren, W., Udalski, A., Bresolin, F., Kudritzki, R.P., Soszynski, I., Szymanski, M., Kubiak, M., 2004, AJ, 128, 281

Soszynski, I, Gieren, W., Pietrzynski, G. 2005, PASP, 117, 823

Udalski, A., Wyrzykowski, L., Pietrzynski, G., Szewczyk, O., Szymanski, M., Kubiak, M., Soszynski, I., Zebrun, K., 2001, Acta Astronomica, 51, 221

Udalski, A., Szymanski, M., Kubiak, M., Pietrzynski, G., Soszynski, I., Wozniak, P., Zebrun, I., 1999, Acta Astronomica, 49, 201.