The Impact of Large-Scale Surveys on Pulsating Star Research
ASP Conference Series, Vol. 203, 2000
L. Szabados & D. W. Kurtz, eds.

Theoretical Distribution of Cepheid Periods in the SMC and LMC

Yann Alibert, Isabelle Baraffe

Centre de Recherches Astronomiques de Lyon, 46 allée d'Italie, 69364 Lyon cedex 07, France

Abstract. We have computed stellar evolutionary models for stars in a mass range characteristic of Cepheid variables for metallicities representative of the Magellanic Clouds populations. These calculations are coupled to a linear nonadiabatic stability analysis in order to get self-consistent mass–period–luminosity relationships. We construct period histograms taking into account a mass function and evolutionary time scales, and we compare them to those given by the microlensing surveys EROS1 and OGLE.

1. Theoretical Predictions

The histograms are constructed using three types of calculations :

- For stellar evolution calculations, we use the Lyon evolutionary Henyey-type code, originally developed at the Göttingen Observatory (Baraffe & El Eid 1991) which includes the latest OPAL opacities, and a treatment of convection by different means – MLT with or without overshooting, and a mixing length equal to $1.5H_{\mathrm{P}}$ or $2.0H_{\mathrm{P}}$, (cf. Alibert et al. 1999; Baraffe et al. 1998).

- The periods are calculated using a linear non-adiabatic stability analysis performed directly on the complete evolutionary models along the tracks. The pulsation calculations are performed with a radial pulsation code originally developed by Umin Lee (Lee 1985). In a first set of calculations, we have neglected the perturbation of convection, while in another set, the convective flux predicted by the MLT is perturbed and included in the linearized energy equation. This is equivalent to the calculations performed by Yecko, Kolláth, & Buchler (1998), when all turbulent terms and time dependence are neglected.

- We construct period histograms taking into account a Salpeter mass function and evolutionary time scales by a coefficient
$$\alpha_i(m_i,t) = \Delta t(i) \times m^{-2.35},$$
where $t(i)$ is the evolutionary time of the model.

2. Comparison to Microlensing Surveys

For the SMC (Fig. 1), the models are compared to the period histogram provided by the EROS-1 collaboration (Sasselov et al. 1997) and by the OGLE

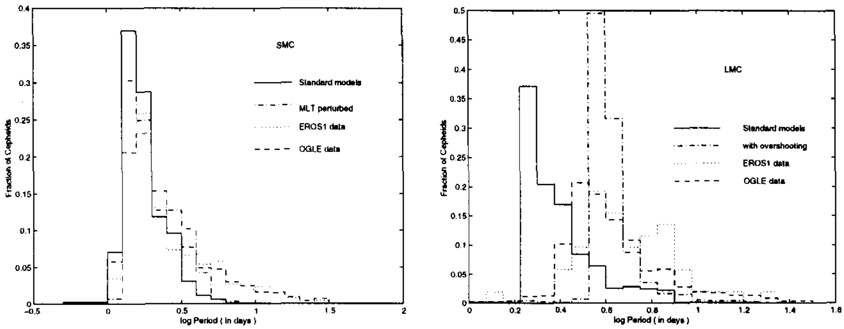

Figure 1. Period histograms for the SMC (left) and LMC (right). Standard model refers to models with a mixing length equal to $1.5H_P$ without overshooting.

collaboration (Udalski et al. 1999). The general shape predicted by models without overshooting is in good agreement with observations. The bulk of observed Cepheids at log $P \sim 0.1 - 0.3$ is correctly reproduced by the models and corresponds to models undergoing a blue loop near 3 $M_\odot$. A similar distribution is obtained for models with a different mixing length parameter. We note also that a simple perturbation of the convective flux given by the MLT (neglecting turbulent and time dependent terms) yields similar results to the standard histogram (frozen convection).

For the LMC (Fig. 1 right), the predicted minimum period is shorter than that observed by EROS1 and OGLE surveys. The same discrepancy appears with the MACHO survey (Alcock et al. 1999). One possible solution is to use models computed with overshooting. In that case, the theoretical and observed histograms agree, but these models fail to reproduce the observed histogram for the SMC. More work is in progress to understand these discrepancies.

References

Alcock, C., Allsman, R. A., Alves, D. R., et al. (The Macho Collaboration) 1999, AJ, 117, 920 [astro-ph/9811240]

Alibert, Y., Baraffe, I., Hauschildt, P., & Allard, F. 1999, A&A, 344, 551

Baraffe, I. & El Eid, M., 1991, A&A, 245, 548

Baraffe, I., Alibert, Y., Méra, D., Chabrier, G., & Beaulieu, J. P. 1998, ApJ, 499, L205

Lee, U. 1985, PASJ, 37, 279

Sasselov, D. D., Beaulieu, J. P., Renault, C., et al. 1997, A&A, 324, 471

Udalski, A., Szymańsky, M., Kubiak, M., et al. 1999, Acta Astron., 49, 201 [astro-ph/9907236]

Yecko, P. A., Kolláth, Z., & Buchler, J. R. 1998, A&A, 336, 553