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

An Analysis of Cepheid Distances Using Bayesian Statistics

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We have applied an approximately Bayesian and a fully Bayesian analysis to the calculation of Cepheid distances, radii and absolute magnitudes using the surface brightness (Baade–Wesselink) method. Both methods successfully account for errors in the data, provide unbiased distance estimates, and provide objective model selection for the radial velocity curve. In addition, the fully Bayesian analysis objectively selects a model for the magnitude curve; averages over models of various Fourier orders, properly weighted by the posterior probabilities of the individual models; and includes a Lutz–Kelker correction.

The approximately Bayesian method is that described by Jefferys & Barnes (1999) and Barnes & Jefferys (1999). It is a maximum likelihood approach with objective selection of the order of the Fourier series model of the radial velocities.

The fully Bayesian method uses a Markov chain Monte Carlo, reversible jump, Gibbs sampler to generate a random sample from the full posterior distribution p(a, b, c, m, n | data), where a and b are m- and n-dimensional vectors of Fourier coefficients for the radial velocities and V-photometry; c is the vector of the parameters of interest (e.g. parallax, angular diameter, phase shift); and m and n are unknown and therefore also to be characterized in the joint posterior probability distribution. We adopted a prior on the distance based on a flattened distribution of Cepheids about the Galactic plane, i.e., $\propto \rho d^2 \delta d \propto d^2 \exp(-|z|/z_o)\delta d$, where ρ is the density of the Cepheid population at the point in question and $|z| = d|\sin b|$ is the distance from the Galactic plane. The latter provides the Lutz–Kelker correction. We ran 10,000 samples per star.

Based on eight Cepheids, the fully Bayesian results confirm the approximately Bayesian results, although the radii are slightly larger in the former. Moreover, the Lutz–Kelker corrections of the fully Bayesian method permit unbiased mean absolute magnitudes to be determined.

References

Barnes, T. G. & Jefferys, W. H. 1999, in ASP Conf. Ser. Vol. 167, Harmonizing Cosmic Distance Scales in a Post-Hipparcos Era, ed. D. Egret & A. Heck (San Francisco: ASP), 243

Jefferys, W. H. & Barnes, T. G. 1999, Bayesian Statistics 6, ed. J. M. Bernardo, J. O. Berger, A. P. Dawid, & A. F. M. Smith (Oxford: Oxford Univ. Press), 777