

Fundamental Stellar Properties from Eclipsing Binary Analyses

E. F. Milone¹, R. Stagg¹,
P. Guhathakurta²,

D. A. Vandenberg³, J. Kallrath⁴

¹Univ. of Calgary, ²Lick Obs./Univ. of California at Santa Cruz, ³Univ. of Victoria, ⁴Univ. of Florida/BASF

Abstract

The properties of the binary components of the eclipsing variables found in 47 Tuc core regions as part of a search for extrasolar planets, and which were described by Milone et al. (2004), and previously in a more generic way by Albrow et al. (2002), have been reexamined following reanalysis of the image photometry and calibrations. This is part of an ongoing study to find fundamental properties of stars of different metallicity in a variety of environments through eclipsing binaries analyses.

The Problem

- For definitive determination of masses, for the scale of the system, RVs as well as photometry (or visual binary astrometry) are needed. For radii we need eclipses.
- What if full data sets are not available? How can solution degeneracy be avoided?

The Solution

- Multi-passband data help (at least for temperatures; color excess complicates it).
- In clusters, even crowded ones, isochrones may provide an alternate lever to get at initial parameters.
- Relative properties of the components attainable.

New Work

- The image processing for the HST FW555 and FW814 passband data was performed by PG and his group at UCO/Lick Observatory, University of California Santa Cruz;

- A new transformation to V and I_c passbands and recalibration of the light curves were carried out by RS;

- New evolution tracks and isochrones have been provided by DAVdB;

- The light curve analyses have been redone by EFM with the newest versions of the Wilson-Devinney program and the WD package of damped least squares, simplex, and simulated annealing programs developed and tested by JK and EFM (Milone & Kallrath 2008; Kallrath & Milone 2009);

- The subsequent analysis follows the method developed by Milone et al. (2004).



Fig. 1. 47 Tuc: The HST search target for planetary transits by Gilliland, et al. (2001). It is a rich cluster: ~50,000 stars available in the HST Planetary Camera frames.

Modus Operandi (for initial parameters): First Stage

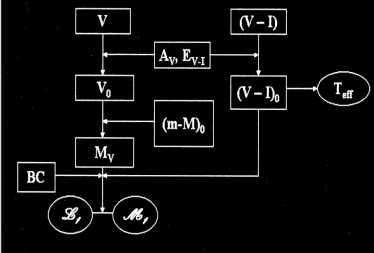


Fig. 2. Two-Stage MO: Procedures to establish initial and unadjusted parameters when only two-color photometry but also a well-established cluster isochrone are available. Many components of this flowchart are now included in the WD (2007) light curve modeling program and the package WDX2007 (Kallrath & Milone 2009).

Modus Operandi (for initial parameters): Second Stage

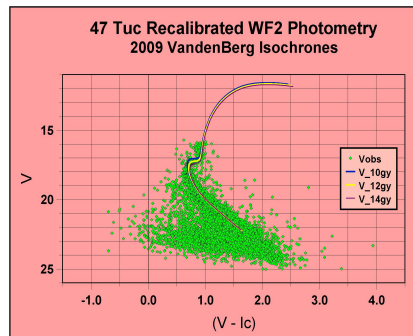
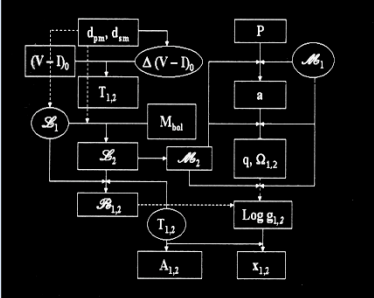


Fig. 3. Newly extracted FW555 and FW814 HST photometry data from PG, calibrated and transformed to V and I_c by RS using the relations established by Dolphin (2009), and 2009 isochrones for 3 ages by DAVdB. The 12 Gy isochrone appears to fit the observational data best. The binaries in this cluster have been remodeled with (m-M)₀ = 13.35, E_{v-Ic} = 0.043, [Fe/H] = -0.75. 6000 synthetic light curves with the properties of stars on an earlier isochrone provided the first initial and unadjusted parameter values.

This work has been supported in part by the Canadian NSERC grants to EFM and DAVdB.

Sample 47 Tuc Transformed & Fitted Data

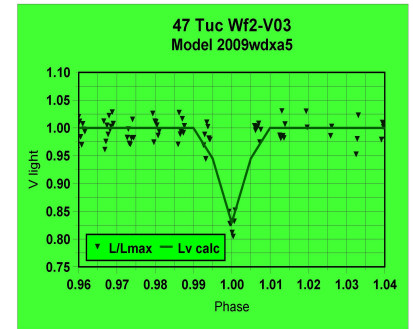


Fig. 4. Phase plotted data for the detached EB WF2-V03. Above: V light curve and fitting near primary minimum. Below: Fitted I_c light curve near primary minimum.

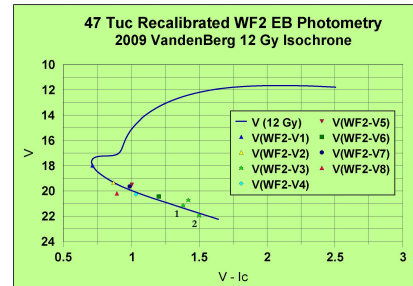
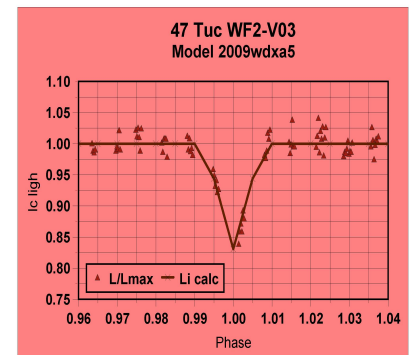


Fig. 5. The 8 eclipsing binaries on the WF2 chip are shown relative to DAVdB's 12 Gy isochrone on the 47 Tuc CMD. The components of the WF2-V03 detached system are also shown; some of their properties are listed below.

WF2-V03 Absolute Parameters

P(d)	i0	L1(V) / L2(V) [4σ]	L1(Ic) / L2(Ic)		
10.0918 ± 0.0031	2451360.771 ± 0.002	8.48 ± 0.26 4.08	8.18 ± 0.27 4.39		
i	T1 / AT	Ω1 / Ω2	R1 / R2	M1 / M2	Mbol / 2
88.10 ± 0.1	4248 215 ± 14	32.5 ± 1.1 33.4 ± 0.4	0.62 R _{sun} 0.52	0.52 M _{sun} 0.46 M _{sun}	7.17 7.77

References

Albrow, M.D. et al. 2002, *ApJ*, 559, 1060
 Dolphin, A.E. 2009, *PASP*, 121, 655
 Gilliland, R.L. et al., 2000, *ApJ*, 545, L47
 Kallrath, J., & Milone, E.F. 2009, *Eclipsing Binary Stars: Modeling and Analysis*, 2nd ed. (New York: Springer)
 Milone, E.F., & Kallrath, J. 2008, in Milone, Leahy, & Hobill, *Short-Period Binary Stars: Observations, Analyses, and Results* (Dordrecht: Springer), 191
 Milone, E.F. et al., 2004, *Rev. Mex., A & A*, 21, 109