Using MECI to Mine Eclipsing Binaries from Photometric Exoplanet Surveys

Jonathan Devor and David Charbonneau

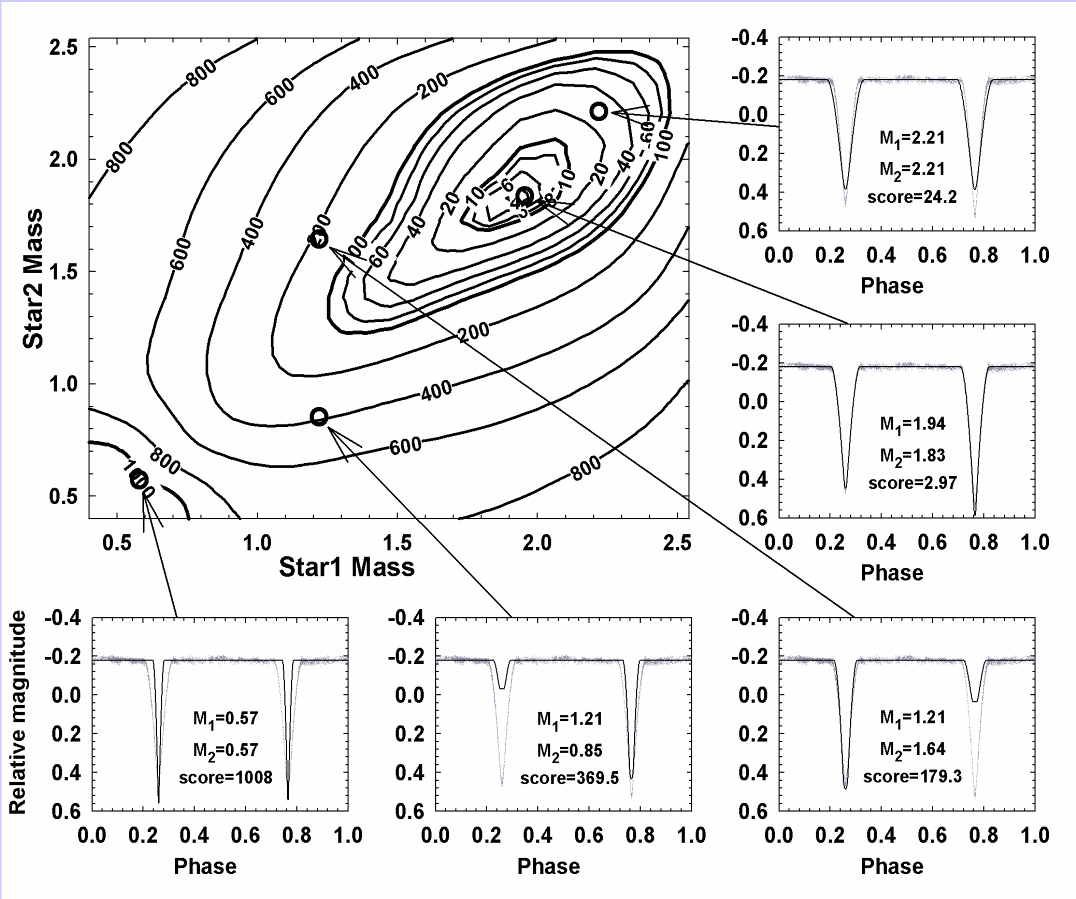
Harvard-Smithsonian Center for Astrophysics

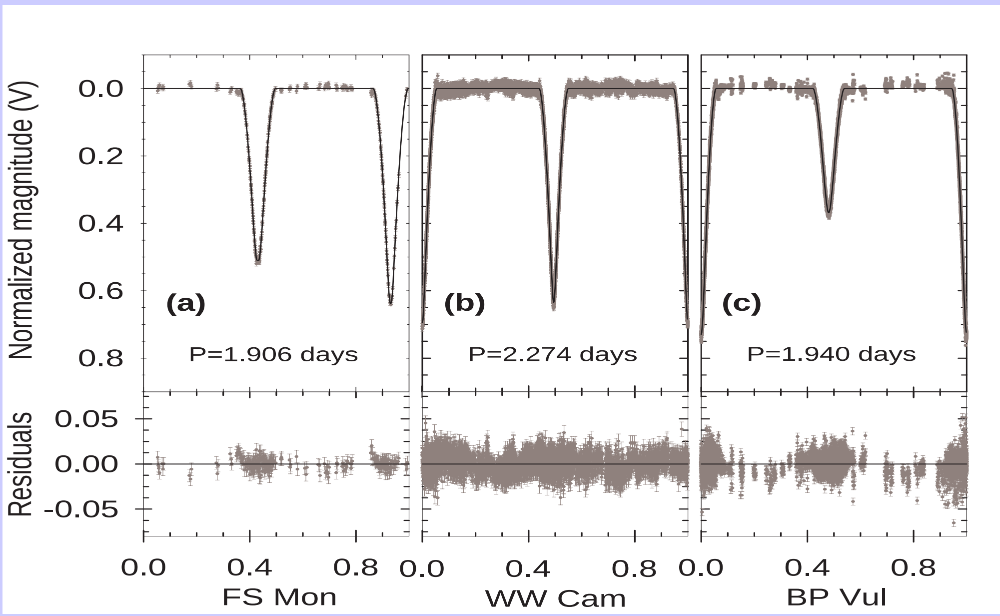
60 Garden Street, Cambridge, MA 02138, U.S.A

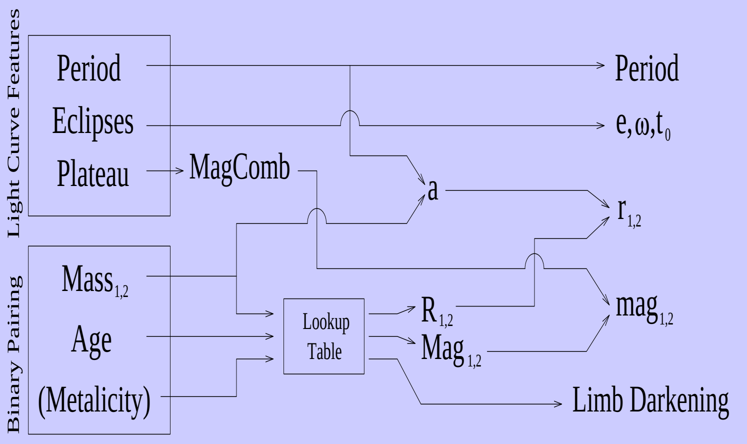
jdevor@cfa.harvard.edu

We describe the Method for Eclipsing Component Identification (MECI), which is an automated method for assigning the most likely absolute physical parameters to the components of an eclipsing binary. MECI is unique in that it requires only the photometric light curve and combined color of the eclipsing binaries. We have implemented this method using published theoretical isochrones and limb-darkening coefficients, and publicly released its source code*. MECI lends itself to creating large catalogues through the systematic analyses of datasets consisting of photometric time series, such as those produced by OGLE, MACHO, HAT, and many others surveys. We will be presenting results of data mining the Trans-Atlantic Exoplanet Survey (TrES). This sort of mining technique may be used for both characterizing stellar populations and for discovering rare and interesting binary systems. Of particular interest are the lower main-sequence stars, for which models underestimate their sizes by as much as 20%. Progress in this area has been hampered by the small number of suitable M-dwarf binary systems with accurately determined stellar properties. Finding additional systems by mining Exoplanet Surveys may provide significant benefits for our understanding of such low-mass stars.

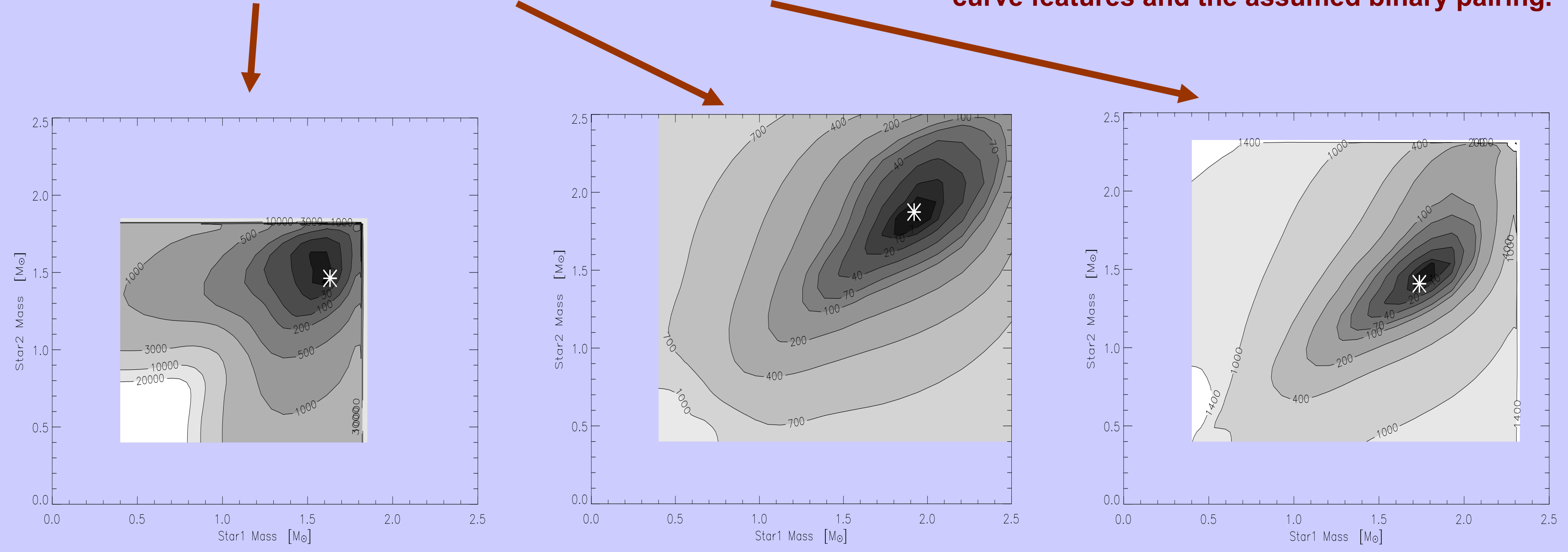
*** The source code and running examples of MECI can be downloaded from:** `http://cfa-www.harvard.edu/~jdevor/MECI.html`



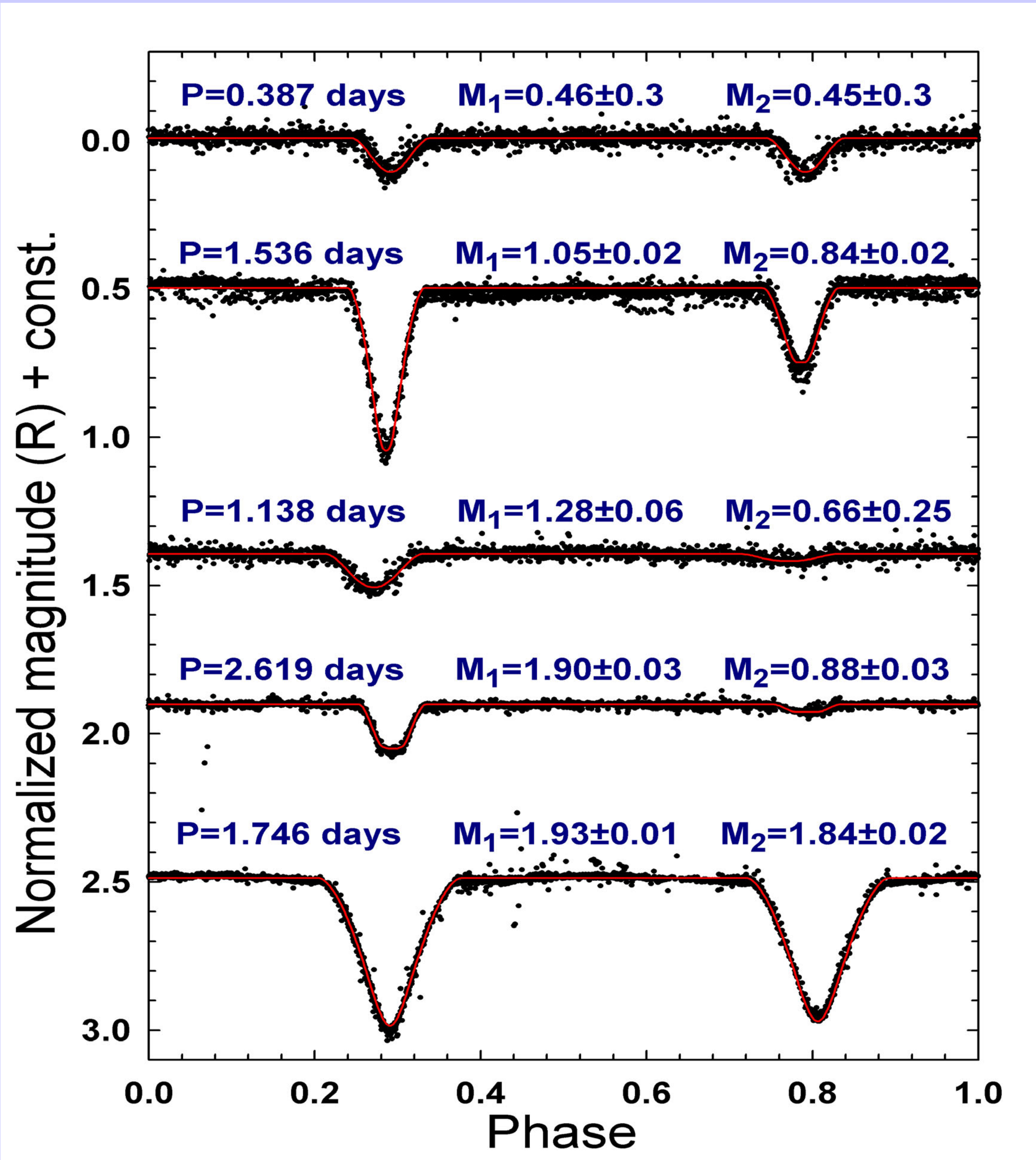


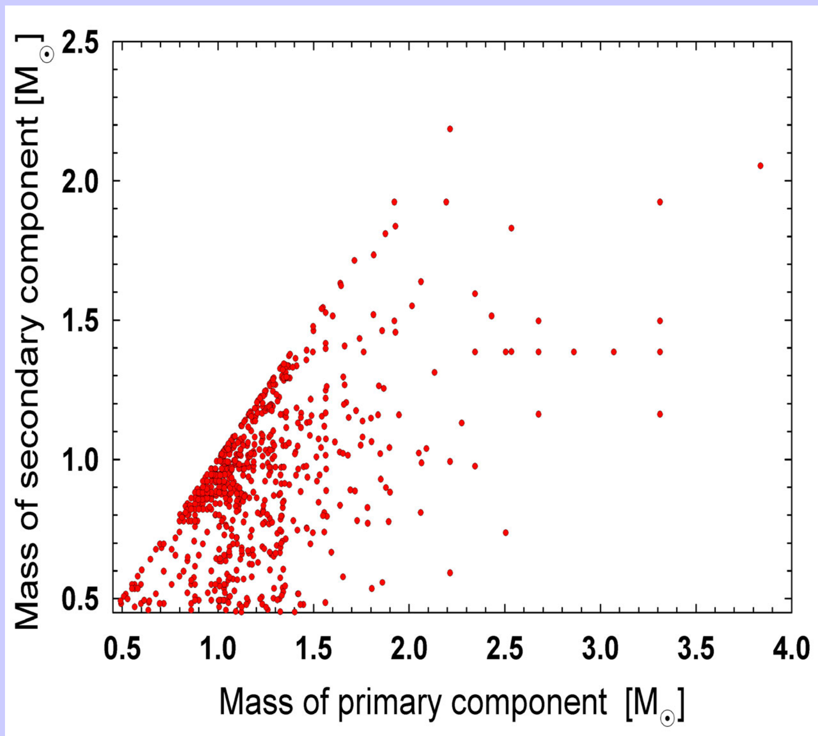


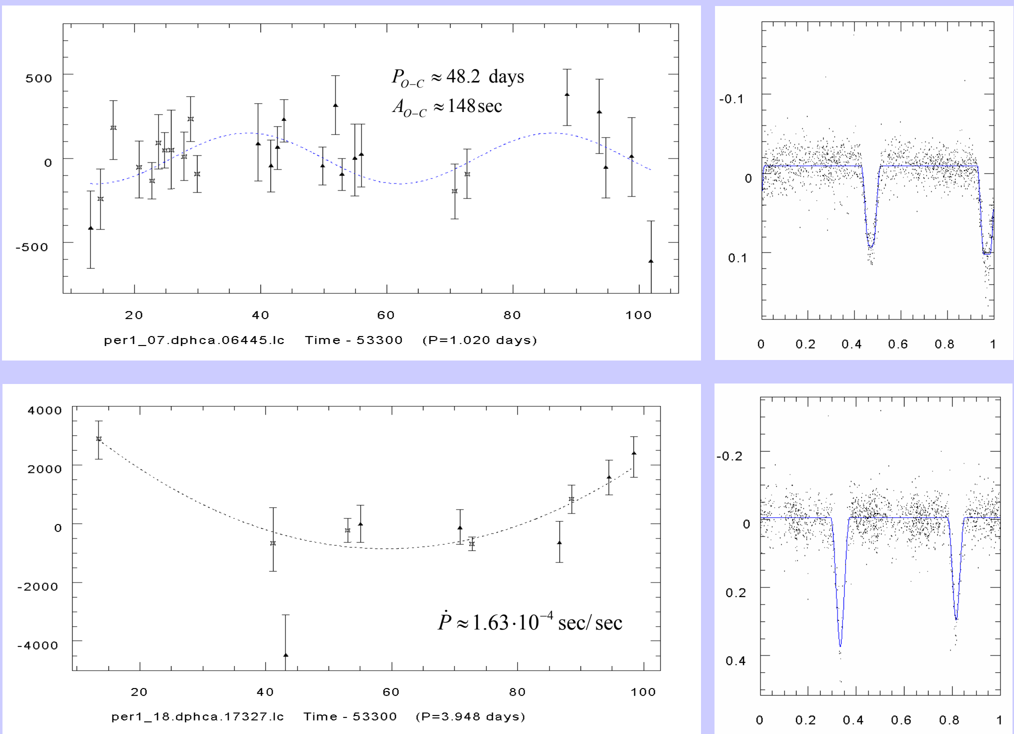
Above: The MECI flow diagram, showing the derivation of the parameters needed to model an EB light curve, starting from the extracted light curve features and the assumed binary pairing.



Above: The observed WW Camelopardalis light curve (Lacy et al. 2002), compared with the simulated light curves of 5 EB pairings. Masses are in solar units.
Above-right: The phased light curves, and the DEBiL model fit (Devor 2004, 2005 ; solid line) with its residuals, for the eclipsing binary systems: (a) FS Monocerotis; (b) WW Camelopardalis; (c) BP Vulpeculae. The light curves were taken, respectively, from Lacy et al. (2000, 2002, 2003).
Right: The corresponding MECI likelihood score contours. The published solution for each binary system (Lacy et al. 2000, 2002, 2003), is marked by a white asterisk.







Left: Mass estimates (in solar units) and best-fit model curves of 5 light curves from the Trans-Atlantic Exoplanet Survey (TrES ; Alonso et al. 2004) obtained using MECI. TrES employs a network of 3 automated telescopes to survey 6° x 6° fields-of-view, in search of transiting extrasolar planets. As a by-product, the survey has generated high-quality light curves of several hundred thousand stars, which we have analyzed with MECI.
Above-left: A mass-mass scatter plot resulting from the MECI analysis of 850 detached EBs from 10 TrES fields.
Above-middle: Eclipse time variations (O-C) of two selected TrES EBs. The top system shows sinusoidal variations, while the bottom system show parabolic variations (i.e. constant period drift). The filled triangles are data from primary eclipses and the open stars are data from secondary eclipses. Their X-axes are HJD, and their Y-axes are in units of seconds.
Above-right: The phased light curves of the two respective EBs. Their Y-axes are in normalized R-band magnitudes.

References

Alonso, R., et al. 2004, ApJ, 613, L153
Devor, J. 2004, American Astronomical Society Meeting Abstracts, 205
Devor, J. 2005, ApJ, 628, 411
Lacy, C. H. S., et al. 2000, AJ, 119, 1389
Lacy, C. H. S., Torres, G., Claret, A., & Sabby, J. A. 2002, AJ, 123, 1013
Lacy, C. H. S., Torres, G., Claret, A., & Sabby, J. A. 2003, AJ, 126, 1905