Highlights of Astronomy, Vol. 13
International Astronomical Union, 2003
O. Engvold, ed.

Semi-detached Binaries as Probes of the Local Group

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The SMC I band light curves of the OGLE project show a curious absence of familiar Algols. Comparitive statistical work for SMC and Milky Way Algols might uncover an evolutionary explanation, presumably connected with chemical composition, or may point to observational selection or even merely perception. As background, LMC and SMC abundances of nitrogen, oxygen, and neon are lower than in our Galaxy by respective factors of about 2.5 and 6, raising the issue of metallicity effects on semi-detached (SD) statistics - specifically on SD light curves and numbers of SDs. Lobe overflow is a *triggered* process, with both system age and structural configuration at triggering dependent on composition.

On another topic, the EB distance scheme's main attraction is directness, as *no calibration of any kind is involved*, allowing distance estimates for individual binaries. *If there were only one EB, in principle we could find its distance.* Only geometric and radiative properties are utilized and evolution is essentially irrelevant. Only the best conditioned EB's are needed for distances to Local Group galaxies, as GAIA will observe EB's in enormous numbers. The value of total-annular eclipses is well known, although luminosity ratios from spectra or SED's restore much of the information otherwise missing in partial eclipse cases. Among several continuing difficulties are third light, aliasing of radii, and observational selection.

Most workers on EB distances to Local Group galaxies actively select well detached binaries (WDB), presumably regarding them as the simplest morphological type. Tacit issues would be 1) whether WDB's simplicity helps with light curve solutions, 2) whether it helps with absolute scaling, and 3) whether WDB's really are relatively simple. The answer to item 1 is *no* - irradiation and static tides are solved problems at the level required for light curve solutions. Relevant to item 2 is a need for improvements in binary spectrum synthesis – the analog of a light curve program for SED's, with solution of the inverse problem for SED's just as one now does for light curves. We also need to convert from relative to absolute theoretical flux correctly. For item 3 one must distinguish among several kinds of simplicity. *Physical* simplicity (few parameters) is the issue for fitting problems. *Application of physics removes free parameters* so - in the way that matters for general solutions and for distances - *SD and over-contact binaries are simpler than WDB's.*

Essentially all SD binaries have sensibly circular orbits because of strong tides. Three parameters are thereby saved, as eccentricity, e, is known, argument of periastron, ω, is inconsequential, and the contact star's rotation is synchronous. Although e and ω are readily found for DB's, every free parameter increases uncertainty by complicating the correlation matrix. The role of mass ratio ($q = m_2/m_1$) is very important for SD and even more important for overcontact (OC) light curves. The situation can be seen in the connection between q and relative (mean) radii, $r_{1,2} = R_{1,2}/a$. There is *no* connection for DB's, except for upper limits on $r_{1,2}$, whereas a known or assumed q immediately fixes *one* radius for an SD and nearly fixes *both* radii for an OC. Complete eclipses are required for strong photometric mass ratios ($q_{\rm ptm}$) for the same reason that complete eclipses are needed for strong measures of $r_{1,2}$, since q estimates essentially come from radius estimates. Note that $q_{\rm ptm}$'s arise from lobe-related radii that are found from eclipses, contrary to a common misconception that they come from tidal deformation inferred mainly from outside-eclipse variation. Eclipses carry most of the information coded into EB light curves, so it follows that observing time is used efficiently where fractional eclipse width is relatively large. Fractional eclipse width is statistically larger for SD's than for DB's and even larger for OC's because it increases with $r_1 + r_2 = (R_1 + R_2)\,a$. Aliasing of radii can impede selection of survey binaries (say from GAIA) for subsequent intensive observation with large aperture telescopes and is reduced for SD's *vis a vis* DB's. Observing radial velocities (RV) for the dim SD secondaries is not easy, with limiting magnitudes for velocities being much brighter than for light curves. A partial remedy is to go to the infra-red where the low temperature secondaries are relatively bright. The most realistic circumvention may be to use spectra for primary star velocities only and complete our mass information with the help of q_{ptm}'s.

The common W UMa OC's are too dim for useful RV observation outside the Milky Way with present technology and luminous OC's are very rare. Circular orbits and synchronous rotation are guaranteed for OC's, thus saving four fitting parameters (e, ω, and two rotations). OC solutions are especially strong because *two* radii must fit into the lobe configuration, compared to one for SD's and none for DB's. Complete eclipses are reasonably common for W UMa's, although not common for high luminosity OC's. Rigorously correct scaling of theoretical flux is important for the distance problem. Distant flux scales with polar normal intensity, and the remaining problem is to find the scaling constants for the components - just two numbers. If a light curve program computes all relative quantities self-consistently, then

$$F_d^{\rm abs} = 10^{-.4\,A}\left[F_{\rm a,1}^{\rm prog}\left(I_1^{\rm abs}/I_1^{\rm prog}\right) + F_{\rm a,2}^{\rm prog}\left(I_2^{\rm abs}/I_2^{\rm prog}\right)\right][a/d]^2\,, \qquad (1)$$

where subscripts *abs* and *prog* refer to absolute flux (F) or normal intensity (I), subscripts d and a are observer distance and standard program distance respectively, and subscripts 1 and 2 are for stars 1 and 2. Absolute I's come from a stellar atmosphere program and program F's and I's come from the program. Observations give F_d^{abs} and semi-major axis a comes from a light/velocity solution. One has all needed quantities except d (and perhaps A), so the relation can be inverted to find d (or $d\,[A]$). To find $I_1^{\rm abs}$ and I_2^{abs} we need polar effective temperatures, $T_{\rm pole}$, which can be estimated by analysis of spectra or SED's.