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Extragalactic Eclipsing Binaries: Astrophysical Laboratories

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Eclipsing binaries (EBs) have long been known for providing accurate stellar fundamental properties, such as masses and radii. These are obtained from the modeling of light and radial velocity curves and, with input data of good quality, uncertainties of a few percent in the components' physical properties are now routinely achieved. Additionally, a number of other observables are determined for eclipsing binaries using techniques similar to those employed for single stars: Effective temperatures from multi-wavelength photometric analysis and chemical abundances from detailed spectroscopic modeling. Thus, EB systems provide a complete characterization of the physical properties of their components, with the added constraint that both stars should have identical age. Also worth mentioning is the ubiquity of EB systems among all kinds of stars. Main sequence stars, variable stars, giants, supergiants, and compact objects, to name a few, are found as members of EBs. This makes EBs excellent "laboratories" for stellar astrophysics. A number of studies have exploited this fact and carried out detailed analysis of galactic EB systems (e.g. Andersen et al. 1991; Clausen 1991; Claret & Giménez 1993; Schröder et al. 1997; Guinan et al. 2000). A few areas where EBs play a crucial role in astrophysics are stellar structure and evolution, tidal evolution, stellar atmospheres, binary evolution in interactive systems, ...

A new perspective has opened in the last decade with the advent of powerful telescopes, detectors and analysis techniques, which have permitted the acquisition of accurate data of EBs in Local Group galaxies. With this comes the possibility of performing detailed stellar astrophysical studies beyond our Galaxy. Worth noting is the great benefit that has experienced this field from the release of the microlensing survey catalogs, which have resulted in a database of thousands of new eclipsing binaries with light curves of excellent quality. Extragalactic EBs provide a unique opportunity to study stars that have formed and evolved in environments with chemical histories that may differ from those of the solar neighborhood. For example, the LMC and SMC are populated with low-metallicity, young massive stars that are no longer found in our Galaxy.

The use of extragalactic EBs as distance indicators has been thus far the main thrust for their study but increasing interest in the astrophysical aspects has developed in the last few years. One straightforward application is the definition of a mass-luminosity (M–L) law. But, to accomplish this, a representative sample of stars are needed and just a handful of EBs currently have physical properties accurate enough, still insufficient for a first establishment of a M–L law outside our Galaxy. More productive thus far has been the study of individual EB systems with the goal of evaluating stellar structure and evolution models. Especially well-suited for such purpose is the LMC EB HV 2274, which has similar components in a moderately evolved stage (close to the TAMS). Ribas et al. (2000) analyzed HV 2274 and performed a critical study of stellar models both using the H-R diagram and the apsidal motion rate (which contains information of the internal structure of the stars). From that, the authors were able to constrain the elusive convective overshooting parameter for metal-poor massive stars. Another example of using extragalactic EBs as astrophysical laboratories was given by Fitzpatrick et al. (2003). In that case, the spectroscopic study of the semi-detached LMC EB HV 5936 provided insight into the atmospheric properties (most notably helium abundance) of the mass-losing component.

These are just a few examples of EBs used as astrophysical laboratories, where the physical properties of the stars themselves were subject of study. Also interesting is the possibility of using extragalactic EBs as probes. For example, the properties of the interstellar medium along the line of sight (strength of the 2175 Å bump or the far-UV rise) can be analyzed from spectrophotometric observations spanning a wide wavelength range (e.g. Ribas et al. 2002). Even more tantalizing is the prospect of using a large ensemble of EBs across a galaxy to study its line of sight distribution. Since the distance can be accurately determined ($\sim$3%) for each EB system individually, once the "mean" distance of the galaxy is subtracted, the residuals may trace the spatial distribution of the young stellar population.

With some five ongoing projects aimed at the determination of physical properties of Local Group EBs (mostly in the LMC), the future of this field looks bright and significant progress is expected in the coming years. In addition, some projects are now focusing on galaxies other than the LMC, such as the SMC, M31 and M33, and opening new grounds for study. Also promising is the possibility of exploring the realm of stars with lower masses (late B- and A-type), which, with a magnitude of about 18 in the LMC, are within the grasp of current instrumentation.

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