Abstract for a general public

Binary stars are key objects for astrophysics. In particular, eclipsing binary stars allow the direct determination of the masses of their components. If the latter can be assumed to have evolved as single stars, they can be used to calibrate standard relations and observables for single stars. Detached eclipsing binary stars also serve as important and accurate distance indicators. Close binary stars interact during their lifetimes and mutually affect their evolution through tides and mass transfer, generating various endpoints of stellar evolution and astrophysical effects such as gamma ray bursts or gravitational waves.

As regards to massive stars it has been realized almost thirty years ago that the masses of single stars as determined from their spectra and theoretical models do not agree: the so-called mass discrepancy. Obviously, something must then not be correct with the models. This ”something” has been traced to mixing processes in the deep stellar interior whose efficiency has been underestimated. This is important because this mixing of material also provides nuclear fuel to the stellar cores that hence become heavier, and the more fuel is available the longer the stars live as ordinary stars.

One of the goals of this project is to test how efficient these internal mixing processes really are. The efficiency of these processes can be determined by deriving the masses and temperatures of the stars in massive eclipsing binary systems, but also by asteroseismology, which uses stellar pulsations as seismic waves to sound the interior of stars, similar to terrestrial seismology that uses earthquakes to derive the inner structure of our home planet. Therefore, a large number of pulsating stars in eclipsing binary systems will be searched for and the most interesting representatives subjected to asteroseismic modelling. The latter is aided by the accurate stellar parameters empirically determined from the binarity, that provide a very well defined set of external constraints.

The second goal of the project deals with a very recently discovered type of pulsators in close binary stars, so called single-sided or tidally tilted pulsators. The pulsation axis of a star in a binary system is usually located normal to the orbital plane, like its rotation axis. For the tidally tilted pulsators, the gravitational force of the companion has however pulled their pulsation axes into the orbital plane and focused the pulsations in one of the stellar hemispheres. Hence one sees the pulsations under all aspect angles over the orbital cycle of the binary. This facilitates observational mode identification and may provide a key that also these stars can be asteroseismically exploited. The present project therefore plans to detect as many tidally tilted pulsators as possible and also to subject the most interesting cases to asteroseismic analysis.

In other words, this project aims at linking the strengths of binary star studies and asteroseismology and to apply this strategy to two selected types of object. To this end, it will first attempt to find a sufficient number of these objects by searching them in data provided by NASA’s Transiting Exoplanet Survey Satellite (TESS) mission. Follow-up observations of the best targets will be conducted at international observatories to help with the steps to follow. The latter comprise determinations of stellar masses and radii, and deciphering the pulsations. With these results in hand, theoretical modelling will lead to the final outcome of the project.

In the end, we should hopefully have calibrated the size of the mass discrepancy in massive stars, understand under which conditions a pulsator becomes tidally tilted, and what defines them as a class. In the course of the process, we should have increased the number of known massive pulsating stars in eclipsing binary systems and tidally tilted pulsators manifold, should have determined masses and radii for a significant amount of high- and intermediate mass pulsators, modelled their interiors determining the amount of internal mixing and in some cases internal rotation profiles, and as important by-products have compiled the most complete catalogues of massive main sequence pulsators and main sequence opacity-driven pulsators in eclipsing binaries to date for use by the community.