1226

66.11

The Stability of Polytopes in Close Binaries

D. Lai (Cornell U.), F. A. Rasio (IAS), S. L. Shapiro (Cornell U.)

We discuss some results of our recent study of hydrostatic equilibrium solutions for polytopes in close binary systems. Using an energy variational method, we have constructed compressible generalizations of the classical incompressible Roche, Roche-Riemann, Darwin, and Darwin-Riemann solutions. Along all Roche and Roche-Riemann sequences, we demonstrate the existence of a point where the total energy and angular momentum of the system simultaneously attain a minimum. A similar minimum exists for Darwin-type binaries when the polytope index n of both components is below a critical value \( n_{crit} \approx 2 \). We show that such a turning point along an equilibrium sequence marks the onset of instability. This instability occurs before the Roche limit is reached in Roche-type binaries, and before the surfaces of the two components come into contact in Darwin-type binaries. We point out the critical importance of this instability in determining the final evolution of coalescing binary systems.

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66.12

Hydrodynamic Instability and Coalescence of Neutron Star Binaries

F. A. Rasio (IAS), D. Lai, and S. L. Shapiro (Cornell U.)

Hydrostatic equilibrium configurations for close neutron star binaries can become unstable. The stability limit for circular orbits occurs at the orbital separation that simultaneously minimizes the total equilibrium energy and angular momentum in the system. The occurrence of such a minimum is a purely Newtonian hydrodynamic effect resulting from tidal interactions. Its existence is independent of the degree of synchronization in the system. For sufficiently homogeneous stars, with effective adiabatic index \( \Gamma > \Gamma_{crit} \), the minimum occurs before the surfaces come into contact. Using an energy variational method to construct the equilibrium binary configurations, we find that \( \Gamma_{crit} \approx 1.5 \) for a synchronized system and \( \Gamma_{crit} \approx 1.8 \) for an irrational system. The development of an instability can drastically affect the terminal evolution of a close neutron star binary whose orbit is decaying by gravitational wave emission. Indeed, the instability causes a rapid acceleration of the coalescence, such that the radial infall velocity at contact is much larger than would be predicted if the stars behaved like point masses.

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66.14

Spectrophotometric Properties of Common Proper Motion Binaries Containing White Dwarf Components: Comparisons to Single Field Stars

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Spectrophotometric indices and photometric parallaxes of over 500 Luynen common proper motion pairs with degenerate components confirm that most are physical pairs which are members of the old disk population. However the sample also contains a significant admixture of extreme subdwarfs of Luynen k and m color class. Preliminary luminosity functions for the CPMB sample white dwarfs and main sequence components are very similar to those determined for visual binaries and single field stars in the solar neighborhood.

The project has yielded over a dozen degenerate components with absolute visual magnitudes near \( M_v=16 \). Though the sample is deep enough to have reached substantially beyond this, degenerate stars in wide binaries fainter than \( M_v=16 \) continue to elude our survey— in accord with Winget et al.'s finding that the observed luminosity function derived from single field white dwarfs is truncated due to the finite age of the Galactic disk (about 9 Gyr). This lower limit on the age of the Universe is incompatible with inflationary models that assume a Hubble constant of 100 km/s/Mpc.

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Session 67: Stellar Shells

Display Session

Pavilion

An Imaging Fabry-Perot Study of the Wolf-Rayet Shell NGC 6888

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NGC 6888 is an oblong, clumpy shell of emission surrounding a WN6 star. It is \( \sim 15' \) long along its major axis, 

\[ \text{minutes of arc} \]

and expanding with a velocity of \( 85 \text{ km s}^{-1} \). The shell is especially prominent in \( \text{H}\alpha \) and [N II], but also has an [O III] 'skin' which is tied to the shell in the NE and SW, but which extends well beyond it in the NW and SE where the shell appears to have been breached. We have used the Wide Field version of the imaging Fabry-Perot system developed for the 60" Palomar telescope to obtain narrow band [O III] and H\alpha images of NGC 6888. The instrument has a 16' X 16' field of view, a total system speed of f/1.65, and a velocity resolution of 20 km s\(^{-1}\).

The spatial resolution was 0.96"/pixel with integration times of 15 minutes for [O III] and 5 minutes for H\alpha at each etalon setting. The [O III] skin around NGC 6888 appears to consist of wind-driven radiative shocks. Material behind the shocks has presumably cooled to the point of photoionization equilibrium with the radiation field of the star. The extremely high ratio of [O III]/H\alpha in these back-illuminated shocks (> 20) shows that they are optically thin to ionizing radiation. Further, the absence of a bright H\alpha halo indicates that the ambient medium has a lower density than was previously claimed, which in turn supports the idea of a significant contribution to the shell from stellar mass loss. Dynamically, shocks to the NW from the break rather than radiating from the star, suggesting a shock driven by internal pressure, and not a simple wind-driven shell. The patterns of these shock velocities around the breaks in the shell allow us to estimate the time at which Rayleigh-Taylor instabilities became important.

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