

EVOLUTION OF LOW MASS BINARIES UNDER THE INFLUENCE OF GRAVITATIONAL RADIATION

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Evolutionary changes of masses and periods under the influence of gravitational radiation (GR) are computed for binaries with main-sequence or degenerate hydrogen-helium (H), helium (He) and carbon (C) secondaries. Tracks in the P - M_2 and P - \dot{M}_2 planes are determined. The orbital period of systems P with a non-degenerate dwarf filling its Roche lobe decreases until the time-scale of GR ($\sim 10^9$ - 10^{10} yrs) becomes shorter than the thermal time-scale τ_{KH} of the mass losing component M_2 . When M_2 becomes $\sim 0.1 M_\odot$, P begins to increase. This could account for the existence of the minimal $P \approx 1.3^h$ and for the accumulation of observed cataclysmic binaries (CB) below $P \leq 2^h$. The GR can be the driving force for evolution of cataclysmic binaries: TT Ari, OY Car, Z Cha, and WZ Sge as their P , M_2 and \dot{M}_2 indicate. The rate of mass exchange driven by GR is $\sim 10^{-9}$ - $10^{-10} M_\odot$ /yrs. It is enough to feed the X-ray bursters and related objects.

In a binary with a degenerate secondary and initial $M_2/M_1 \geq 0.6$ the secondary may transform into a disk around the primary during several orbital periods, liberating the energy of $\sim 10^{50}$ ergs. It appears that close binaries with both components degenerate may be the most powerful source of background GR near the Earth: $F \approx 10^{-5}$ - 10^{-6} erg/cm²/sec.

The secondaries of CB have deep convective envelopes. Stellar winds are inherent in such stars, which may lead to a substantial angular momentum loss through magnetic braking. If the time-scale of the angular momentum loss is 10^{-9} - 10^{-10} yrs, the resulting evolution of CB will be similar to that dominated by GR.

DISCUSSION

Van den Heuvel: Can you explain the very high X-ray luminosities of the ~ 20 X-ray sources in the galactic bulge, which have $L_X > 10^{37}$ erg/sec, requiring $10^{-9} M_\odot$ /yr mass transfer? To my recollection, gravitational radiation-driven mass transfer from a red dwarf companion can never give

more than a few times $10^{-10} M_{\odot}/\text{yr}$.

Tutukov: The mass exchange rate strongly depends on the assumed mass-radius relation. But up to now theory and observation can not provide us with reliable information about it. Our models show that a mass exchange rate in the range $10^{-9} - 10^{-10} M_{\odot}\text{yr}^{-1}$ is possible. To me, it seems possible that a black hole can sometimes be one component of such a system. It is possible also that a magnetic stellar wind might sometimes provide the mass exchange.

Van den Heuvel: I would like to point out that Ostriker and Żytkov, and Rappaport and Joss are independently doing similar calculations and are obtaining similar results, namely when the companion mass becomes $\leq 0.1 M_{\odot}$ the system expands again.

Tutukov: That is natural because of increasing interest in low mass binaries in the last few years.

Sato: What is the final state of a system evolving due to the emission of gravitational radiation? Is it the collapse or the destruction of the binary system?

Tutukov: Systems initially having main-sequence components and evolving due to gravitational radiation finish their evolution as binaries with component masses $\sim 0.03 M_{\odot} + \sim 1 M_{\odot}$ and a period $\sim 1^{\text{h}}$. Close binaries with degenerate components and having an initial mass ratio $q \geq 0.6$ transform into single stars surrounded by a heavy disk in a few orbital timescales. The same systems, but having $q \leq 0.6$, remain binaries with component masses $\sim 3 \times 10^{-3} M_{\odot} + \sim M_{\odot}$ (see Figure 1 in my review talk).