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 $\gtrsim 1.3^h$ 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 $M_2/M_1 \gtrsim 0.6$ 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 $\gtrsim 10^{-5}$ - 10^{-6} erg/cm^2 /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

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more than a few times 10^{-10} $M_\odot$/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} $M_\odot yr^{-1}$ 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 $\lesssim 0.1$ $M_\odot$ 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 ~0.03 $M_\odot$ + ~1 $M_\odot$ and a period ~$1^h.5$. Close binaries with degenerate components and having an initial mass ratio $q \gtrsim 0.6$ transform into single stars surrounded by a heavy disk in a few orbital timescales. The same systems, but having $q \lesssim 0.6$, remain binaries with component masses ~3×10^{-3} $M_\odot$ + ~$M_\odot$ (see Figure 1 in my review talk).