THE WHITE DWARF MASS AND ORBITAL PERIOD DISTRIBUTION IN ZERO-AGE CATACLYSMIC BINARIES

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I. INTRODUCTION

A zero-age cataclysmic binary (ZACB) we define as a binary system at the onset of interaction as a cataclysmic variable. We present here the results of calculations of the distributions of white dwarf masses and of orbital periods in ZACBs, due to binaries present in a stellar population which has undergone continuous, constant star formation for 10^{10} years.

II. METHOD

Distributions of ZACBs were calculated for binaries formed t years ago, for log t = 7.4 (the youngest age at which viable ZACBs can form) to log t = 10.0 (the assumed age of the Galactic disk), in intervals of log t = 0.1. These distributions were then integrated over time to obtain the ZACB distribution for a constant rate of star formation. To compute the individual distributions for a given t, we require the density of systems forming (number of pre-cataclysmics forming per unit volume of orbital parameter space), $n_f(t)$, and the rates at which the radii of the secondary and of its Roche lobe are changing in time, $\dot{R}_s(t)$ and $\dot{R}_{L,s}(t)$, respectively. In calculating $n_f(t)$, we assume that the distribution of the orbital parameters in primordial (ZAMS) binaries may be written as the product of the distribution of masses of ZAMS stars (Miller and Scalo 1979), the distribution of mass ratios in ZAMS binaries (cf. Popova, *et al.*, 1982), and the distribution of orbital periods in ZAMS binaries (Abt 1983). In transforming the the orbital parameters from progenitor (ZAMS) to offspring (ZACB) binaries, we assume that all of the orbital energy deposited into the envelope during the common envelope phase leading to ZACB formation goes into unbinding that envelope. $\dot{R}_{L,s}(t)$ is determined from orbital angular momentum loss rates due to gravitational radiation (Landau and Lifshitz 1951) and magnetic braking (γ = 2 in Rappaport, Verbunt, and Joss 1983). We turn off magnetic braking if the secondary is completely convective.

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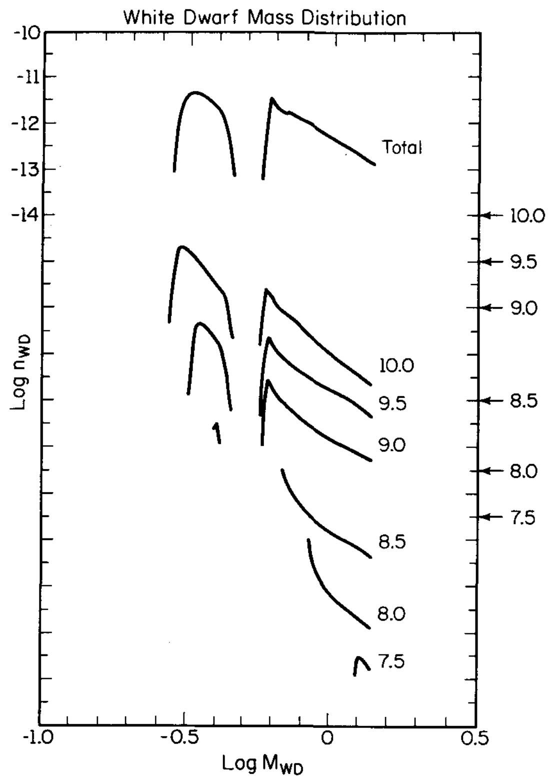

Fig1: The distribution of the white dwarf masses in ZACBs resulting from a constant stellar birthrate over 10^{10} years (curve labeled "total"), and the contributions to this distribution from systems formed "t" years ago for several values of t (curves labeled by values of log t). M_{WD} is the mass of the white dwarf in solar masses and n_{WD} is the number of CVs forming per year per log white dwarf mass per unit area of the Galactic plane (in pc^2). An absolute scale is provided for the total distribution. The distributions for individual values of log t are plotted on a relative scale having the same spacing as the absolute scale. For the purposes of comparison, log n_{WD} = -10 for each distribution is indicated on the right-hand scale by an arrow labeled with the corresponding value of log t.

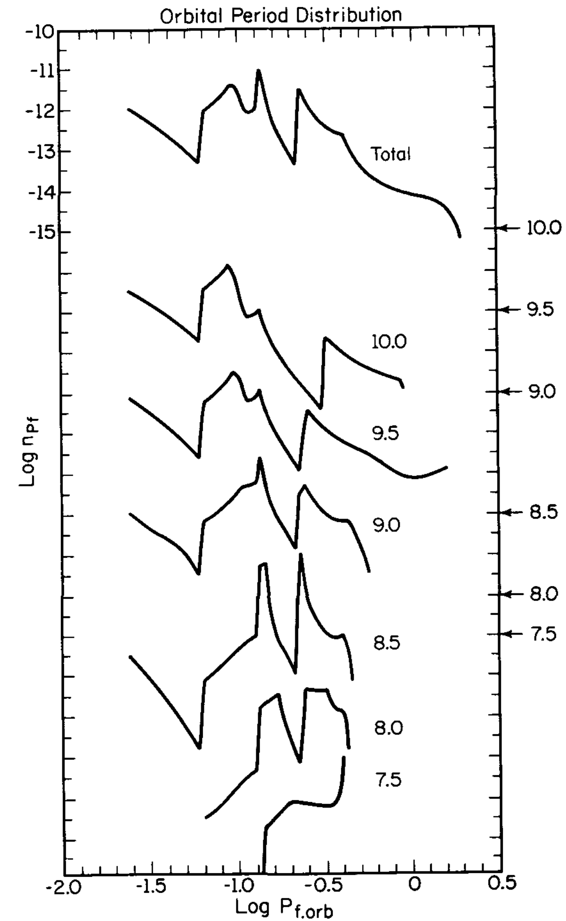

Fig. 2: The orbital period distributions of ZACBs for the same cases as in Fig. 1 $P_{f,orb}$ is the orbital period in days and n_{pf} is the number of CVs forming per year per log orbital period per square parsec. The scale used on the y-axis is explained in the caption to Fig. 1.

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III. RESULTS

Figures 1 and 2 show the results of these calculations. Our principal conclusions may be summarized as follows:

- Cataclysmic variables (CVs) first appear in a stellar population at an approximate age log t = 7.4 years. This is the smallest age at which close binaries leave white dwarf remnants.
- The distribution of white dwarf masses in ZACBs is not sufficient to account for the observed high white dwarf masses in CVs, emphasizing the possible importance of selection effects (Ritter and Burkert 1986; see also Politano, Ritter, and Webbink, these proceedings).
- The orbital period distribution identifies four main subsets of ZACBs: (1) short-period systems containing He white dwarfs (peak near log P = -1.1); (2) systems with CO white dwarfs whose secondaries are convectively stable against rapid mass transfer to the white dwarf (peak near log P = -0.9); (3) systems with CO white dwarfs whose secondaries are radiatively stable against rapid mass transfer (peak near log P = -0.65); and (4) long period systems with evolved secondaries (wing out to periods of roughly 2 days).
- The period distribution of ZACBs has a local minimum between 2 and 3 hours, due to the discontinuity in white dwarf masses between CVs containing He white dwarfs and systems containing CO white dwarfs (cf. Webbink 1979).
- CVs forming from binaries less than 10^9 years old do not contain He white dwarfs.
- The formation rate of CVs is maximized when the nuclear time scale of the initial primary is comparable to the time scale for angular momentum loss during the pre-CV state. In this case, pre-CV systems are brought into contact roughly as fast as they are formed (emerge from the common envelope phase).

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