White Dwarfs in Ultrashort Binary Systems

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1 Introduction

White dwarf binaries are thought to be the most common binaries in the Universe: in our Galaxy their number is estimated to be as high as $10^8$. In addition, most stars are known to be part of binary systems, roughly half of which have orbital periods short enough that the evolution of the two stars is strongly influenced by the presence of a companion. Furthermore, it has become clear from observed close binaries, that a large fraction of binaries that interacted in the past must have lost considerable amounts of angular momentum, thus forming compact binaries, with compact stellar components. The details of the evolution leading to the loss of angular momentum are uncertain, but generally this is interpreted in the framework of the so-called “common-envelope evolution”: the picture that in a mass-transfer phase between a giant and a more compact companion, the companion quickly ends up inside the giant’s envelope, after which frictional processes slow down the companion and the core of the giant, causing the “common envelope” to be expelled, as well as the orbital separation to shrink dramatically [55].

Among the most compact binaries known, often called ultra-compact or ultra-short binaries, are those hosting two white dwarfs and classified into two types: detached binaries, in which the two components are relatively widely separated and interacting binaries, in which mass is transferred from one component to the other. In the latter class a white dwarf is accreting from a white dwarf like object (we often refer to them as AM CVn systems, after the prototype of the class, the variable star AM CVn; [56, 28]).

In the past many authors have emphasised the importance of studying white dwarfs in double-degenerate binaries (DDBs). In fact, the study of ultrashort white dwarf binaries is relevant to important astrophysical questions that have been outlined by several author. Recently, [32] listed the following ones:
Double white dwarfs are excellent tests of binary evolution. In particular the orbital shrinkage during the common-envelope phase can be tested using double white dwarfs. The reason is that for giants there is a direct relation between the mass of the core (which becomes a white dwarf and so its mass is still measurable today) and the radius of the giant. The latter carries information about the (minimal) separation between the two components in the binary before the common envelope, while the separation after the common envelope can be estimated from the current orbital period. This enables a detailed reconstruction of the evolution leading from a binary consisting of two main sequence stars to a close double white dwarf [26]. The interesting conclusion of this exercise is that the standard schematic description of the common envelope – in which the envelope is expelled at the expense of the orbital energy – cannot be correct. An alternative scheme, based on the angular momentum, for the moment seems to be able to explain all the observations [30].

Type Ia supernovae Type Ia supernovae have peak brightnesses that are well correlated with the shape of their light curve [35], making them ideal standard candles to determine distances. The measurement of the apparent brightness of far away supernovae as a function of redshift has led to the