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ORIGINAL ARTICLE

Investigation of some physical properties of accretion induced collapse in producing millisecond pulsars

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Abstract We investigate some physical characteristics of Millisecond Pulsars (MSPs) such as magnetic fields, spin periods and masses, that are produced by Accretion Induced Collapse (AIC) of an accreting white dwarf (WD) in stellar binary systems. We also investigate the changes of these characteristics during the mass-transfer phase of the system in its way to become a MSP. Our approach allows us to follow the changes in magnetic fields and spin periods during the conversion of WDs to MSPs via AIC process. We focus our attention mainly on the massive binary WDs ($M \gtrsim 1.0 M_{\odot}$) forming cataclysmic variables, that could potentially evolve to reach Chandrasekhar limit, thereafter they collapse and become MSPs. Knowledge about these parameters might be useful for further modeling of the observed features of AIC.

Keywords Stars: neutron stars · White dwarfs · Cataclysmic variables · X-ray binaries · Fundamental parameters

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1 Introduction

Cataclysmic variables (CVs) are short-period binary systems consisting of massive white dwarfs (WDs) primary that is accreting material via Roche-lobe overflow from low-mass secondary stars (see i.e. Warner 1995; Warner and Woudt 2002; Middleton et al. 2011), so Accretion Induced Collapse (AIC) is favorable in these systems (van den Heuvel 2004). The AIC scenario has been proposed as an alternative source of recycled pulsars sufficient to obviate the difficulties with the standard model (Bhattacharya and van den Heuvel 1991; Hurley et al. 2010). While other authors questioned the viability of an AIC origin for the recycled pulsars on theoretical and statistical grounds (Romani 1990; van den Heuvel 1995), Ferrario and Wickramasinghe (2008a, 2008b) argued that the AIC channel can form binary Millisecond Pulsars (MSPs) of all observed types with $B \sim 10^{8-9}$ G, $P \sim 20$ ms and $e \sim 0.44$ (e.g. Bhattacharya and van den Heuvel 1991; Lorimer 2008; Wang et al. 2011). The required conditions for the formation of an AIC in the case of a steady accretion were summarized in Nomoto (1984, 1987), Isern and Hernanz (1994) and in two recent works (Hurley et al. 2010; Chen et al. 2011). Unless the accretion rates are very high ($> 10^{-7} M_{\odot}\,\mathrm{yr}^{-1}$), the accreted (Hydrogen) matter will not go into steady nuclear burning on the surface of the WD, and hence its mass will never grow. In the situation of lower accretion rates, the accreted matter will burn in Super Novae (SN) type Ia, such that the WD will never reach Chandrasekhar limit ($1.44 M_{\odot}$).

Nowadays, there is an increasing amount of evidence which points to the fact that at least a fraction of low-mass X-ray binaries (LMXBs) should be the result of AIC of a WD in a low-mass binary system (Taam and van den Heuvel 1986; Li 2010). However, this straightforward hy-