Chapter 40
Unveiling Accreting White Dwarf Binaries in Hard X-Ray Surveys

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Abstract Among hard X-ray sources detected in the *INTEGRAL/IBIS* and *Swift/BAT* surveys, those identified as accreting white dwarf binaries recently boosted in number, representing ∼20 % of the Galactic sample. The majority are identified as Cataclysmic Variables with magnetic white dwarf primaries suggesting that this subclass could be an important costituent of the galactic population of X-ray sources. In this paper I present the results of an on-going follow-up progamme in the X-rays aiming at identifying the true nature of newly discovered sources.

40.1 Introduction

Since mid-1970s, accreting white dwarf (WD) binaries were known as sources of X-rays, belonging to the broader class of Low Mass X-ray Binaries (LMXBs) but a few tens were known. Thanks to a prominent soft X-ray emission (kT $\leq$ few eV), about few hundreds were detected in the *ROSAT* All Sky Survey (RASS) [1–3]. These include Cataclysmic Variables (CVs) (most non-magnetic Dwarf Novae (DNs) in quiescence and magnetic polars), AM CVn and Super Soft X-ray sources, the latter encompassing Novae in the Milky Way and in the Magellanic Clouds.

Our view of the X-ray sky has today dramatically changed thanks to the recent deep *INTEGRAL* and *Swift* hard X-ray surveys with more than 1,000 sources detected above 20 keV [4, 5]. The *INTEGRAL/IBIS* extensive survey of the galactic plane has shown that our knowledge of the Galactic X-ray binaries was poor, surprisingly detecting a large number of Catalysmic Variables (CVs), most (∼70 %) of the magnetic Intermediate Polar (IP) type [4, 6]. The complementary *Swift/BAT* survey mainly covering high latitudes, still confirms the high (∼60 %) incidence

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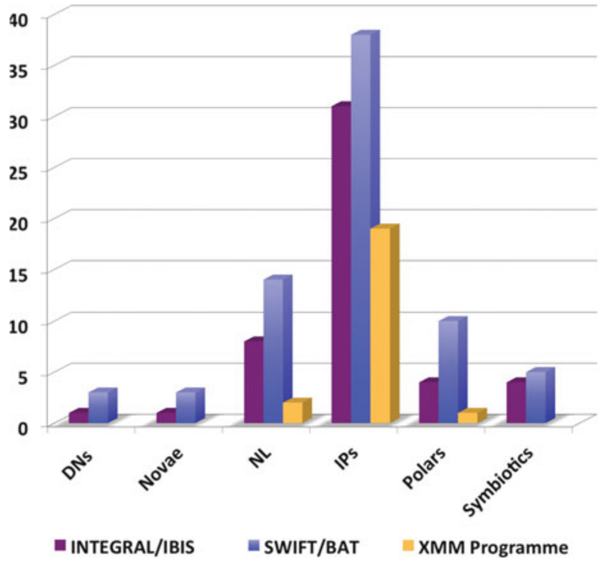

Fig. 40.1 The distribution of CV types detected by *INTEGRAL* and *Swift* using latest catalogue releases (misidentifications were corrected). Identified systems from our follow-up programme are also shown

of IPs. Figure 40.1 shows the CV types detected in both surveys that include of DNs, Nova-like (NLs) (many are disputed to be magnetic), old Novae, Symbiotics and the magnetic IPs and polars. IPs are believed to harbour weakly magnetized accreting white dwarfs (WDs) ($\leq$10 MG), whilst polars contain strongly magnetized (B $\sim$ 10–240 MG) primaries. Basic differences are the asynchronous WD rotation (P_{spin} $\sim$mins) and a hard optically thin ($kT_{brem.}$ $\sim$20–40 keV) emission in the IPs, whilst the polars have orbitally-locked ($P_{spin=orb}$ $\sim$hrs) WDs and possess a strong soft optically thick (kT_{bb} $\sim$30–50 eV) emission. The current roster of hard detected CVs totals to 72 systems representing $\sim$20 % of Galactic X-ray sources in these surveys.

The existence of an extended population of yet unrecognized low-luminosity X-ray sources of galactic origin contributing to the X-ray background (XRB) was already suggested at the time of *ROSAT* survey [7]. A decade later deep *Chandra* observations of the Galactic centre revealed thousands of dim sources and ascribed to CVs of the magnetic IP type [8]. This was corroborated by further pointings of Galactic bulge fields [9, 10]. Observations with *INTEGRAL*, *Rossi-XTE Suzaku* and *XMM-Newton* satellites also allowed to resolve the Galactic X-ray Ridge Emission (GRXE) into thousands of discrete low-luminosity sources mainly attributed to IPs [11–14]. However the true contribution to the X-ray luminosity function at faint levels is still disputed as well as the true space densities of these binaries [15, 16]. The knowledge of X-ray binary populations is crucial to understand close binary evolution. The high (∼20 %) incidence of magnetism in CVs with respect to that in single WDs (∼10 %) would either imply that CV formation is favoured by magnetism or CV production enhances magnetism [17].

The negligible absorption in the hard X-rays and the flux limits of the *INTEGRAL* and *Swift* surveys can allow one to detect magnetic CVs up to ∼1 kpc (∼ 10^{33} erg s^{-1}), hence to obtain the first volume-limited sample of these systems.

40.2 Results from X-Ray Follow-Ups

The newly identified hard X-ray sources require follow-ups. While optical spectroscopy [18–20] provides first selection of suitable candidates, the true nature can be inferred through the detection of X-ray pulses at the WD spin period (that implies magnetically channeled accretion) and the study of broad-band X-ray spectra. To this purpose we are pursuing a follow-up programme for faint sources with *XMM-Newton* and for bright sources also with *NuSTAR*.

Among 24 new sources observed so far we could classify 20 IPs, 2 hard NLs and a hard polar [21–26]. We also disproved a CV classification for XSS J12270-4859 which we identified as a LMXB, unexpectedly associated with a high energy *Fermi/LAT* source [27, 28] and recently found to be one of the few transitional millisecond pulsar binaries [29, 30]. To date 56 IPs are confirmed of which 41 detected in the hard X-ray surveys. The polar group instead amounts to ∼100 systems with only 10 identified as hard sources.

Magnetic accretion produces a strong shock above the WD magnetic poles below which the flow cools by bremsstrahlung (hard X-rays) and cyclotron optical radiation that are partially thermalized and re-emitted in the soft X-rays and/or EUV/UV domains. The efficiency of these cooling mechanisms depends on the magnetic field strength: cyclotron is increasingly efficient in high field systems (polars) and is able to suppress high temperatures [31]. It is then likely that low-field systems (IPs) preferentially emit hard X-rays. Since 3 hard X-ray polars are also slightly desynchronised, asynchronism seems a common characteristics. Early attempts to relate the hard X-ray emission with the degree of asynchronism fail with the current enlarged sample which now includes short period and weakly desynchronised IPs (Fig. 40.2) and 10 polars with field strengths ranging from 7 to 40 MG. Other parameters such as the WD mass could play a role, but significantly massive primaries are not favoured [24]. The local mass accretion rate is also a key parameter under investigation.

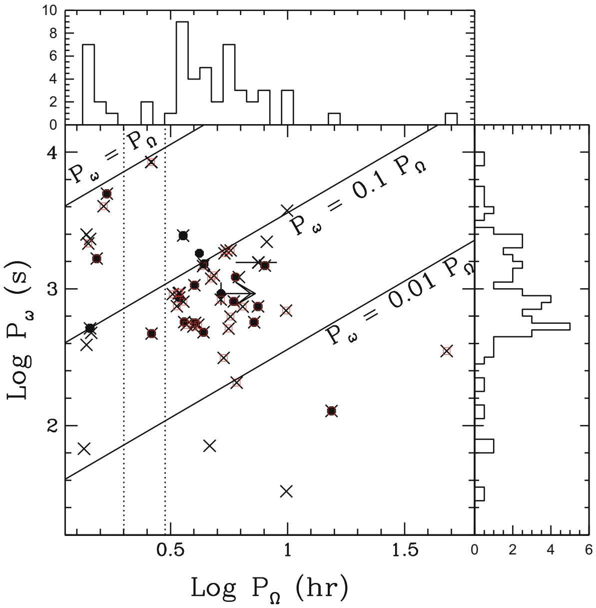

Fig. 40.2 The spin-orbit period plane of confirmed IPs (*crosses*) including our programme targets (*filled circles*). The *solid lines* mark synchronism and two levels of asynchronism (0.1 and 0.01). *Vertical lines* mark the orbital CV gap. The spin (*right panel*) and orbital (*upper panel*) period distributions are reported. Hard X-ray IPs are marked as *red boxes*

While previously known systems were concentrated in a limited range of the spin-orbit period plane, the new identifications enlarged it at long orbital periods ($\geq$5 h) and below the 2–3 h orbital period gap (Fig. 40.2), where mCVs are expected to have reached synchronism [32]. The discovery of these short orbital period IPs may hint to a low-luminosity population yet to be unveiled [16].

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