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WHERE ARE THE MAGNETIC WHITE DWARFS WITH DETACHED, NONDEGENERATE COMPANIONS?

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ABSTRACT

The Sloan Digital Sky Survey has already more than doubled the sample of white dwarfs with spectral classifications, the subset with detached M dwarf companions, and the subset of magnetic white dwarfs. In the course of assessing these new discoveries, we have noticed a curious, unexpected property of the total lists of magnetic white dwarfs and of white dwarf plus main-sequence binaries: there appears to be virtually *zero* overlap between the two samples! No confirmed magnetic white dwarf has yet been found in such a pairing with a main-sequence star. The same statement can be made for the samples of white dwarf–M dwarf pairs in wide, common proper motion systems. This contrasts with the situation for interacting binaries, in which an estimated 25% of the accreting systems have a magnetic white dwarf primary. Alternative explanations are discussed for the observed absence of magnetic white dwarf–main-sequence pairs, but the recent discoveries of very low accretion rate magnetic binaries pose difficulties for each. A plausible explanation may be that the presence of the companion and the likely large mass and small radius of the magnetic white dwarf (relative to nonmagnetic degenerate dwarfs) may provide a selection effect against the discovery of the latter in such binary systems. More careful analysis of the existing samples may yet uncover members of this class of binary, and the sample sizes will continue to grow. The question of whether the mass and field distributions of the magnetic primaries in interacting binaries are similar to those of the isolated magnetic white dwarfs (including those in wider binaries) must also be answered.

Key words: binaries: close — novae, cataclysmic variables — stars: magnetic fields — white dwarfs

1. INTRODUCTION

Among the many results of the Sloan Digital Sky Survey (SDSS; York et al. 2000) has been the near doubling of the number of spectroscopically classified white dwarfs (WDs). A catalog of 2551 mostly new WDs from the first SDSS data release (DR1) is published in Kleinman et al. (2004). Separate papers on the magnetic white dwarfs (magWDs) are those of Gänsicke et al. (2002), Schmidt et al. (2003), and Vanlandingham et al. (2005). The 106 new magWDs presented in these papers brought the total number to 169, the vast majority of which have fields $B \gtrsim 2$ MG.

Frequently, the WDs in the SDSS are accompanied by an unresolved or barely resolved main-sequence (MS; nearly always M dwarf) companion in a composite spectrum. Raymond et al. (2003) studied 109 of these in more detail, with the main goal of finding close pairs that might be pre–cataclysmic variables (PCVs). They found that the WDs are at least fairly hot, in the $T_{\rm eff}$ range 8000–42,000 K. With the release of the third SDSS data set (DR3), some 501 such pairs have been discovered. A detailed discussion of this sample is given in Silvestri et al. (2004).

In the course of assessing these new SDSS discoveries, we have noticed a curious, unexpected property of the total samples of magWDs and WD+MS stars: there appears to be virtually *zero* overlap between the two samples! We see that the absence of confirmed magWD primaries applies to all known WD+MS pairs, regardless of source.

Of particular interest is the possible relevance of this curious property to the origin of magnetic cataclysmic variables (magCVs). Wickramasinghe & Ferrario (2000) point out that some 25% of known CVs are magCVs. A lot of progenitors have to be accounted for. The catalog of Ritter & Kolb (2003) includes 113 likely PCVs, none of which is known to harbor a highly magnetic WD. For a large number of these, however, the hot component is a subdwarf or even an MS star. Thus, the subset that is clearly WD+MS is not large enough for a significant test of the fraction that might be magCVs.

To be sure, several PCVs detected in X-ray and EUV radiation show strictly periodic variability, attributed by several authors to the rotation of a WD with accretion-darkened magnetic poles. These systems include V471 Tau (Barstow et al. 1992), IN CMa (Dobbie et al. 1999), and RX J1016−0520 (Vennes et al. 1997). Sing et al. (2004) offer the same explanation for very low amplitude periodic variations observed in the optical photometry of HS 1136+6646. In all cases the strength of the invoked magnetic field appears to be too small for detection by Zeeman-split absorption lines or polarimetric observations. In all the magWDs reported by Schmidt et al. (2003), the fields were strong enough for discovery from spectral features—generally $\gtrsim$2–3 MG. It should be clearly understood that field strengths below this value cannot be ruled out for the degenerate components of the WD+MS pairs.

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It should also be noted that most of the polars (or AM Her systems), the subset of magCVs in which the magnetic primary is locked in synchronous rotation with its mass-losing companion, spend substantial fractions of their time in low-accretion states. During such states the observed spectrum is usually dominated by the photospheres of the magWD and (generally) an M dwarf. Polar systems in low states could conceivably also be found among the spectra of a sufficient number of WD+MS composites. In at least one case, EF Eri, the secondary star's photosphere is not detected in low-state optical spectra nor very clearly even in the infrared (Harrison et al. 2003, 2004). The secondary may be a substellar object, potentially detectable only because of irradiation from the hotter primary star.

In §§ 2 and 3 we discuss the statistics and the expected numbers of magWD+MS pairs, both from composite spectrum objects and from wide common proper motion pairs. In §§ 4 and 5 we discuss two separate hypotheses to explain the quandary encountered earlier. Contradictory evidence for each hypothesis is presented. While no clear explanation is achieved, we think it is important to point out the discrepancies that exist. The current situation is assessed in § 6.

2. THE EXPECTED FRACTION OF WD+MS PAIRS

The WDs and WD+MS pairs have been found in both color and proper-motion samples. These are subject to selection biases, the most obvious of which is that the more luminous MS stars can hide their WD companions. Proper-motion catalogs are, of course, subject to kinematic bias in favor of high-velocity stars. Catalogs of hot WDs such as the Palomar Green Survey (Green et al. 1986, hereafter PG) were usually constructed from blue-sensitive spectra and spectrophotometry, making it easy for a faint nondegenerate companion to be missed. The McCook & Sion (1999) WD catalog is also unsuitable, because the spectra resulting from prior classifications in the literature are of a heterogeneous nature and usually lack coverage at red wavelengths. There is also little effort in this catalog to document the known companions, except in special cases. The SDSS has homogeneous spectrophotometry extending in wavelength to 1 μm. However, the selection criteria for targeting a given point source for a follow-up spectrum are complicated. Therefore, the observed fraction of the WD+MS sample is not a reliable determination of the true fraction for all WDs.

The sample of 109 known WDs within 20 pc of the Sun (Holberg et al. 2002) has more complete information available than for any survey we can think of using. Those authors argue that the sample is complete to a distance of about 13 pc, while the completeness drops to 65% at 20 pc. The full sample has 21 WDs with known nondegenerate companions. This sample is arguably close to being complete in the search for nondegenerate stellar companions and is therefore free from strong selection bias. Thus, we can assume that the 19% ± 4% fraction is a reasonable estimate of the frequency of WD+MS pairs among all WDs.

Another sample for which a systematic search for M dwarf companions has been undertaken is that of Holberg & Magaral (2005). They used the published Two Micron All Sky Survey Point Source Catalog to look for infrared (*JHK*) excess for DA WDs from the PG survey, which are studied in Liebert et al. (2005). Of the 347 stars, 254 had a reliable measurement of at least the *J* magnitude. Already, 34 of these showed prior evidence (i.e., a composite spectrum) of an M companion. They found 25 new candidates showing IR excesses over the expected Rayleigh-Jeans tail of the best-fit model and another 15 stars with probable excesses. Thus, 29% ± 5.5% of this hot WD sample probably have M dwarf companions. This is, of course, a lower limit, since a more luminous nondegenerate companion could exclude a WD from the UV-excess selection used by PG. This sample is not only larger but has a temperature distribution more similar to that of the SDSS WDs considered here. Like the SDSS, the IR-excess stars all have composite spectral energy distributions.

If the magWDs had nondegenerate companions with frequencies similar to those of the two samples discussed above, then 169 magWDs ought to have included 32 ± 6 with such companions using the nearby WD sample and 49 ± 7 using the PG sample. We reiterate that no conclusive cases have yet been found. That magWDs avoid nondegenerate companions in comparison to nonmagnetic WDs appears to be a statistically significant statement, subject to any selection effects.

3. SEARCHES OF WD+MS PAIRS

3.1. *The SDSS Composite Pairs*

As mentioned in § 1, some 501 objects with composite WD+MS spectra have been identified from the SDSS releases through DR3. For 473 of these, the quality and nature of the spectrum of the WD is sufficient to rule out a surface field strength $\gtrsim$3 MG. The field would have to have been discovered from Zeeman-splitting of H lines for 465 DA+MS pairs or of He I lines for eight DB+MS composites. Excluded from consideration are eight DC+MS pairs, as well as 19 more for which the signal-to-noise ratios of the spectra were insufficient to show good line profiles for the WD component. Basically, a star may be counted as nonmagnetic if the spectrum is of good enough quality for WD parameters ($T_{\rm eff}$, log g) to be determined. To be sure, one DAH magWD has been found that shows variable narrow emission lines of hydrogen. While no red continuum excess is detected in the spectrum out to nearly 1 μm, it is likely that this WD has an unevolved, possibly substellar companion. This intriguing object (SDSS 121209.31+013627.7; Schmidt et al. 2003) will be discussed in a separate paper. Since its exact nature is not clear as of the time of this writing, this likely binary system is not considered further but may prove to be a special exception to the main thesis driving this paper.

Given the special interest in finding progenitors of magCVs, it is worth noting that probably very few of these WD+MS composite spectra objects are likely to be CV progenitors. In our incomplete follow-up spectrophotometry attempting to detect periodic radial velocity variations, seven DA+MS pairs have been found to have periods $\lesssim$7 hr. These have separations small enough to be considered PCVs. Silvestri et al. (2004) discuss this sample in detail. Note that most of the WD+MS pairs in the nearby star sample of Holberg et al. (2002) would be unresolved at the distances of the PG and especially the SDSS survey stars, but only one of the 21 nearby WD+MS binaries is close enough to be considered a PCV. (The exception is the variable RR Cae [WD 0419−487], DA6+dM6 system, with a 7.29 hr orbital period.)

Is there some way to estimate how many magWDs would be expected in such a sample if they appear with equal frequency to those in WD samples as a whole? There is an important selection effect that may work against the discovery of magWDs in a magnitude-limited sample. It has been known for many years that magWDs are often massive (Liebert 1988; Sion et al. 1988), but recent analyses of the PG WDs have also shown that magWDs have substantially higher *average* mass than do nonmagnetic WD samples (Liebert et al. 2003, 2005). A greater mean mass implies that the magWDs have smaller radii, a difference that enters as the cube when considering a volumetric sample. As an example, only 2% (eight) of the 341 well-studied DA and 15 well-observed DB WDs in the complete PG sample had detected magnetic fields. Consideration of the mass difference increases this fraction to nearly 10% (Liebert et al. 2003; Kawka et al. 2003) or even higher when the stars with weaker fields detectable only with spectropolarimetry are added to the mix (e.g., Schmidt & Smith 1995; Aznar Cuadrado et al. 2004).

An appropriate comparison for the apparent magnitude-limited SDSS should be PG; therefore, arguably only 2% of the 473 WD+MS pairs should harbor a magnetic primary star, or about 9.5 ± 3 cases. Thus, the absence of a single magWD primary among these pairs is interesting but not of great statistical significance. Indeed, for all WDs found through DR1, 38 new magWDs out of a total of 2551 cataloged in Kleinman et al. (2004) is consistent with a 2% discovery fraction.

Adding to this is an additional negative selection effect for binaries: the WD must compete against the radiation from its companion. If the magWDs are unusually high in mass, they will be more easily hidden. Since virtually all the WD+MS pairs considered here include MS stars of early to very late M spectral type, WDs are detected with $T_{\rm eff}$ down to about 8000 K. For a massive magWD, the temperature limit may be appreciably higher, although it is difficult to believe that magWD primaries should not be detectable in a large sample, if they exist.

3.2. *Wide Common Proper Motion WD+MS Pairs*

Oswalt et al. (1991, 1993, 1996) began a study of common proper motion binaries (CPMBs) thought to contain a WD star as one of the system components. The majority of these 511 CPMBs were identified by Luyten (1969, 1979) and Giclas et al. (1971, 1978). Follow-up observations to obtain *BVRI* and *JHK* photometry were carried out by Smith et al. (1991) and Smith (1997). More recently, Silvestri (2002) and Silvestri et al. (2005) have cataloged spectroscopic observations for several of these systems. These systems have angular separations ranging from $<2''$ to several arcminutes, with an average of about $15''$. The physical separation of the pairs is about 100–10,000 AU. The typical system contains a secondary that is, on average, 2.5 mag fainter than the primary, so the effective limiting discovery magnitude is about $m_{\rm pg} \sim 18.5$ for the primaries. Because of the large physical separations of these systems, this sample may not have any obvious relevance to the origin of CV progenitors; however, it does provide a well-studied control sample.

The photometry data (Smith et al. 1991; Smith 1997; J. A. Smith et al. 2005, in preparation) are most complete in *BVRI*, where 411 systems have been observed. In *JHK*, 149 systems (or components) have been observed. Most of these, but not all, have data for all three bands. Of these, there are 70 spectroscopically confirmed WDs separated from their companions by more than $15''$. Of these 70, seven (10%) show an indication of infrared excess, suggesting a possible companion.

Of the 191 WD+dM pairs and triple systems in Silvestri's latest spectroscopy compilation, 99 contain a DA, 11 a DB, 10 a DQ, six a DZ, and 63 a DC WD as a system component. For the 126 WDs with spectral features, no magWDs were found. However, the resolution of these spectra (>10 Å) is markedly lower than that obtained by the SDSS. Furthermore, the carbon bands and metallic features are generally less discernible than H and He lines. Clearly, magWDs are not necessarily detectable down to several megagauss field strengths with the current observations. The magWD might have a significantly better chance of discovery if it has at least some spatial separation from a more luminous, nondegenerate companion.

Careful inspection of the wide WD+MS spectroscopic sample suggests that there may be as many as five candidate magWD+MS pairs. However, without more precise spectrophotometry or polarimetric measurements, the case is not conclusive for any of these candidates. In light of the typical 100–10,000 AU separations of these wide binaries, it would not be surprising if the incidence of magnetism among these CPMB WDs were more like the incidence among single WDs, since binary interaction could not have played a significant role in the WDs' formation (Wood & Oswalt 1992). Further investigation of these candidates is warranted.

4. DISCUSSION: ARE THE COMPANIONS MORE LUMINOUS?

One possible explanation of the results of §§ 2 and 3 is that the magWDs can have nondegenerate companions, but the companions are preferentially more luminous than the typical M dwarfs paired with nonmagnetic WDs. Massive WDs are generally believed to evolve from more massive progenitors, and recent population synthesis calculations suggest that this is also likely to be the case for magWDs (Ferrario & Wickramasinghe 2005). One may conjecture that a more massive WD progenitor might usually have a more massive companion. If the mass ratio distribution were scale-free (i.e., a power law), $f(q)\,dq \sim q^a\,dq$, then one would expect the frequency of secondaries of mass M_2 to vary with M_1 as $n(M_2)\,dm_2 \sim M_1^{a-1}$.

Because the radius increases with increasing mass on the MS but decreases with mass for WDs, a scale-free mass ratio distribution results in the magWD being even more easily hidden in a typical binary. There might be little chance to discover the magWD, apart from the *Extreme Ultraviolet Explorer* (*EUVE*) and *ROSAT* all-sky surveys at EUV and X-ray energies. Indeed, significant numbers of hot WD companions to B–K MS stars were found in these surveys (e.g., Marsh et al. 1997; Vennes et al. 1997), although none is known to be a magWD. Discoveries of magWDs from *EUVE* and *ROSAT* (*without* nondegenerate companions) include WD 1439+750 (Vennes et al. 1999) and WD 0317−855 (Barstow et al. 1995; Vennes et al. 2003).

Another way of evaluating the possibility of luminous nondegenerate companions is from our understanding of possible progenitors to magCVs (polars and intermediate polars [IPs]). Here the evidence may point in a different direction. Of particular interest may be the recent discoveries of magCVs of such low accretion rates that they are barely brighter than the WD+MS photosphere and are at best weak X-ray sources (Schwope et al. 1999; Szkody et al. 2003, 2004). It appears that the accretion rates are so low ($\dot{M} < 10^{-12}\ M_\odot\ {\rm yr}^{-1}$) that it is doubtful they have yet established Roche lobe contact. Rather, the accretion is argued to be due to a captured stellar wind from the secondary star, whose field lines are fully linked to those of the magWD primary (Li et al. 1995; Webbink & Wickramasinghe 2005).

In each of the five known cases, the secondary star is an M dwarf and the binary period is $\lesssim$5 hr. There would seem to be no way that the secondary could have lost enough mass to evolve from a more luminous MS star to an M dwarf. As they evolve to a shorter period, each should become a normal, high accretion rate polar or IP. Moreover, Schmidt (2005) makes the case that these systems are perhaps as numerous in a given magnitude-limited sample as the Roche lobe–filling accreting magCVs. Thus, it would seem that magCV progenitors often *do* have M dwarf companions, and this evidence does not support the hypothesis proposed earlier in this section.

5. DISCUSSION: DO THE magWD+MS PAIRS HAVE SMALLER SEPARATIONS?

The very fact that the progenitor of the magWD is likely, on average, to be 2–3 times more massive than that of a nonmagnetic WD implies that the evolution in the PCV phase could be different. The path to a CV begins with common envelope (CE) evolution of a WD core and nondegenerate companion. Friction in the envelope results in the decrease of the orbital separation. To produce a future CV, this must bring them close enough that, after they emerge from the ejected envelope as a PCV, the combination of magnetic braking (Verbunt & Zwaan 1981) and gravitational radiation can bring them into contact within billions of years. It is normally assumed that the fields in magWDs are "fossils," present in the core of the original (possibly Ap, Bp type) MS star (Angel et al. 1981; see also § 4.5 of Wickramasinghe & Ferrario 2000). If the core were already magnetic at the beginning of the CE phase, this property might facilitate the dragging inward of the secondary. They might then emerge from the CE already, or very nearly, in the CV phase. This would account for an observed paucity of magWD+MS progenitors.

However, it is difficult to understand how the magnetic field of the degenerate core could have a significant effect on the ejection of the CE. Even for relatively high WD magnetic moments, $\mu \sim 10^{34}$ G cm^3, the energy density in the magnetic field outside the core is $\sim 10^8$ times smaller than the ambient energy density (gas plus radiation) in the CE. A casual look at the bias in CE survival rates for more massive initial primaries (producing more massive, i.e., magnetic, WDs) suggests that, for a nondegenerate companion of a given mass, binaries may actually emerge from the CE with *larger* separations, on average, than for less massive initial primaries. This is because the former are more extended and luminous on the giant branch, so their envelopes have smaller net binding energies.

Regős & Tout (1995) propose instead that strong magnetic fields may actually be generated during CE evolution by the interaction of the spiraling-in stellar cores, the differential rotation, and the convection of the envelope. This would be a kind of α-ω dynamo (Cowling 1981). This theory supposes that the WD core may not originally have been strongly magnetic at all. Rather, it is the efficiency with which this dynamo operates during the CE phase that determines (1) how close the separation of the stellar components becomes and (2) the magnetic field strength of the primary of the future CV. Regős & Tout propose that this mechanism provides quite naturally for the range of field strengths seen in CV WD primaries—for polars, IPs, and less magnetic stars. However, it is not possible at this time to predict with any accuracy the *distribution* with field strengths that results from the interaction. The efficiency of the mechanism may not depend greatly on the masses of either stellar component.

That PCVs generally *can* come out of the CE phase with small separations is proven by the discoveries of close binary central stars of planetary nebulae (Bond & Livio 1990; DeMarco et al. 2004). The central star of A41, in particular, appears to have an orbital period of 2 hr 43 minutes, and it may thus enter the CV phase very soon (Grauer & Bond 1983). Although the hot subdwarf O primary of A41 is not known to be magnetic, the radius is much larger ($\sim 0.1\ R_\odot$) than its future WD radius. When it becomes a WD, any field could be amplified on the order of 1000 times, perhaps rendering it detectable as a magWD. However, it should be noted that the masses of the components are not well determined (e.g., Green et al. 1984). Bruch et al. (2001) even propose an alternative model in which the system is not a PCV but rather consists of two subdwarf O stars of similar brightness.

This scenario suggests that the magnetic CV phase should begin when the magWD is hot. Here one faces a problem with the observational evidence. In particular, the polars are known to harbor magWD primaries that are all at least fairly cool (5000–20,000 K; Sion 1999; Szkody et al. 2003), whereas nonmagnetic WDs in CVs have temperatures up to 50,000 K at orbital periods of 3–6 hr.

The temperatures of IPs are harder to determine, but the few available are near 20,000 K (Sion 1999; Linnell et al. 2002). These have generally higher accretion rates. The surface of the WD may be maintained at a higher $T_{\rm eff}$ because of both compressional heating and the retained energy from nova eruptions. The latter presumably occurs more frequently than for the lower accretion rate polars. The polar magWDs may appear closer to $T_{\rm eff}$ values reflective of their internal energies (central temperatures), and the magWDs may be cooling at closer to the normal rate.

It has also been proposed that the high accretion rate class of CVs called SW Sex variables have magCV primaries (Patterson et al. 2002). The argument is that the accretion "smothers" the primary's magnetic field, rendering it more difficult to detect and slowing the evolution to the synchronous polar state (Hameury & Lasota 2002). A few SW Sex stars are possible IPs, as claims have been made for detections of circular polarization (Rodríguez-Gil et al. 2001, 2002), although most of these systems may show no convincing evidence of circular polarization (Stockman et al. 1992). It is also worth noting that the amplitudes of the claimed detections are only a fraction of 1%, similar to the claimed upper limits for others. If the WD does have a substantial magnetic field, it appears possible that the polar state can be deferred until the magWD is cool. That is, the IP and/or SW Sex stars harbor the hotter magWDs. The secondaries should also be more luminous, and their luminosity and mass should decline with decreasing orbital period. Therefore, it appears to be a plausible hypothesis that the magCV binaries come out of the CE with generally close separations and thus with a smaller probability of observation as magnetic PCV systems. They may come into contact as high accretion rate systems with a fairly luminous secondary and with the primary's magnetic field difficult to detect. As the period shortens and the secondary is whittled down in mass, the system may enter the IP and/or polar phases.

However, the apparently numerous, low accretion rate, "detached" magCVs discussed in § 4 consist of *cool* WDs that may be accreting via a wind from a detached M dwarf companion. The cooling age of the magWDs demands that they have existed in a PCV state for gigayears. The existence of these systems again completely contradicts the hypothesis advanced earlier in this section.

6. RESOLVING THE QUANDARY

In this paper we have documented an interesting and unexpected fact: that the growing samples of magnetic white dwarfs (magWDs) and white dwarf plus M dwarf binaries from mainly the SDSS and common proper motion samples may not yet intersect. The only plausible explanation we have been able to identify is that the presence of the companion and the likely smaller than average radius of the magWD may provide a strong selection effect against the latter's discovery in such binary systems. If the origin of strong magnetic fields is the same for the WDs in close binary systems as for single degenerate stars, it would seem inescapable that magWD+M binaries *must* exist at PCV separations. Arguably, they should exist at larger separations as well. It is up to the community to learn how to find them. The continued growth in sample sizes should also help.

The problem certainly calls for more careful analysis techniques. Lemagie et al. (2004) are proceeding with just such a study using the SDSS pairs. To reduce the contamination from the companion, a template spectrum for the low-mass companion is being fitted and subtracted, and the resulting smoothed Balmer absorption-line profiles are being compared with magWD models at a variety of field strengths to obtain limits on field strength for a given case. In this fashion, some of the candidates may actually yield detections. Polarimetric and spectropolarimetric follow-up observations are planned. More precise work on the WD component of the wide binaries is underway as well.

If the quandary can be explained by the high mean masses of the magWDs, at least one remaining issue has to be addressed. One would then expect that the primaries of magCVs would also be more massive than average WDs. To date, the evidence for or against this is inconclusive (Bailey 1995), based primarily on radii determined for several polar systems that eclipse and inferences based on characteristics of the accretion itself. Improvements in these determinations must await future improvements in the techniques. The radii and masses of the primaries may be determined more accurately when submilliarcsecond trigonometric parallaxes are available from future space missions such as *GAIA* and the *Space Interferometry Mission*.

The alternative formation mechanism for magCVs during the CE phase (Regős & Tout 1995) could allow the mass and field distributions of single magWDs and close binaries, i.e., the polars and IPs, to differ. Since they presumably form and evolve like single stars, the massive WDs in the wider binaries (dominant in these samples) can still be masked by their companions. MagWDs from the alternative magnetic dynamo formation mechanism, however, would still be found among the PCV population. It was pointed out in § 1 that this sample size remains too small for reliable statistics. The temperature distribution of magCV primaries poses a problem. Hence, the resolution of our quandary and even the formation mechanism(s) of magnetic fields in WDs must await further studies.

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