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The Ritter-Kolb Catalogue and its Impact on Research into CVs, LMXBs and related Objects

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Abstract

In the first part of this paper, the Ritter-Kolb catalogue (RKcat for short), its history and a few examples of its application to research in the field of cataclysmic variables are briefly described. In a second part we look forward to possible future applications of RKcat for the study of cataclysmic variables, low-mass X-ray binaries and related objects. Last but not least we also briefly comment on the future of the RKcat service itself.

Keywords: cataclysmic variables - cataclysmic binaries - low-mass X-ray binaries - post-common envelope binaries - catalogues.

1 Introduction

Thirty years after the first public circulation of the *Catalogue of Cataclysmic Binaries, Low-Mass X-ray Binaries and Related Objects*, the so-called Ritter catalogue or Rcat for short (Ritter 1982) it is perhaps a good time to look back at its history and some of its applications to research in the field of cataclysmic variables (CVs), low-mass X-ray binaries (LMXBs) and related objects, and at the same time to also look ahead to possible future applications of what later became to be known as the Ritter-Kolb catalogue (Ritter & Kolb 2003), hereafter RKcat for short. But before discussing the history and the future of RKcat let us briefly summarize for those who are not familiar with RKcat what RKcat actually is, i.e. its purpose, which information it does provide and how it can be accessed.

1.1 RKcat: what is it?

Ever since it was conceived Rcat (up to 1998) and later RKcat (from 1998 onwards) has provided a comprehensive compilation of detached and semi-detached post-common envelope binaries with known (or suspected) orbital periods. The restriction to systems with “known orbital period” is important for two reasons: First, knowing the orbital period of a binary not only provides important information about the object in question, but it is usually also a sure sign for the object having undergone serious examination to some degree, and that more is known about it than just its position

on the sky, its apparent magnitude, and that it may be variable. Second, restriction to systems with known orbital period also considerably limits the number of objects to be dealt with which is anyway growing at an alarming rate (see below).

Among the semi-detached systems we then have CVs (with at least one white dwarf (WD) component) and LMXBs (with either a neutron star or a black hole primary and usually a non-degenerate companion, but low-mass WDs do also occur). Among the detached systems, in Rcat/RKcat referred to as “related objects”, we have “white dwarf”-red dwarf binaries and “white dwarf”-“white dwarf” binaries (double degenerates), where a “white dwarf” is either a genuine WD or an immediate precursor of a WD such as a sdB- or sdO-star. Not included in Rcat/RKcat among the detached systems are binary radio pulsars although some of them do in fact match the criteria for inclusion among the “related objects”. The reason for excluding binary radio pulsars is because they are well documented elsewhere (Manchester et al. 2005).¹

1.2 RKcat: what does it contain?

RKcat provides information about each object in tabular form, a list of references to the most relevant recent literature, a list of references to published finding charts and a comprehensive cross reference list of alias object designations. In the tables (separate for CVs, LMXBs and related objects) we provide object designations, the position on the sky (α , δ), information about the object

¹The data are available electronically at <http://www.atnf.csiro.au/research/pulsar/psrcat>.

type/subtype, apparent magnitudes, periods (above all the orbital period, but also the superhump period and the spin period of the WD (in CVs), or of the neutron star (in LMXBs)), the spectral types of the components as well as other orbital and stellar parameters (orbital inclination, mass ratio, masses, radii) to the extent that these quantities are known.

The purpose of the cross reference list of alias object designations (appropriately called “whoswho”) is to help avoid confusion about object identity. Many objects have a long history during which they have been given many different names by different authors. Thus confusion about an object’s identity can simply arise because earlier authors can of course not refer to later object designations. But also going backwards in the literature does not always reveal even the more common alias names. The “whoswho” list is an attempt to remedy that situation and to nail down an object’s identity in addition to its identification on a finding chart.

The most recent release of RKcat at the time of writing (Ritter & Kolb 2003, update RKcat7.20 as of 30 June 2013) contains information about 1093 CVs, 104 LMXBs and 483 related objects, i.e. of 1680 objects in total.

1.3 RKcat: how can it be accessed?

Whereas earlier editions of Rcat/RKcat appeared in print (Ritter, 1982, 1983, 1984, 1987, 1990; Ritter & Kolb 1995, 1998) the current (7th) edition (Ritter & Kolb 2003) is available in electronic form only from websites at The Open University (OU) at <http://physics.open.ac.uk/RKcat> and at the Max-Planck-Institut für Astrophysik (MPA) at <http://www.mpa-garching.mpg.de/RKcat>, and in slightly different form but with the same content from the Strasbourg Astronomical Data Center (CDS) at <http://cdsarc.u-strasbg.fr/viz-bin/Cat?B/cb>.

The main difference between the versions provided by the OU/MPA websites and the CDS website is that the former provide the tables in a two lines per object format with delimiters which allows for easy visual inspection of the tables on a computer screen, whereas the CDS tables come in a one line per object format which (even without the delimiters) is much too wide for that purpose. Rather they are designed to be processed electronically.

Many more copies of RKcat are available from various other websites. But because the contents of these copies is beyond our control we do not take responsibility for the content of any other than the above-mentioned sources.

2 A Brief History of Rcat/RKcat

Compiling data on CVs for what was later to become Rcat actually began already in 1973, i.e. 40 years ago, as part of the first author’s (hereafter HR) PhD project (Ritter 1977). Although at that time there was no intention whatsoever to produce a catalogue, compiling data on CVs, LMXBs, and related objects continued also beyond the end of the PhD project, and it was around 1978/79 that rumors about the existence of this compilation began to spread among colleagues, some of whom did not hesitate to ask for copies. Dutifully, hand-written copies of the compilation were produced and circulated among a few privileged individuals. In that context, one must realize that at that time neither the internet nor email did exist, and electronic storage of data on computers was unavailable - the storage media of choice were either hand-written files or punched cards - and consequently, there was no easy way of editing and updating such a data base.

Bogdan Paczynski was among the first to whom a copy was sent upon his request. And based on the distribution of the orbital periods of the 43 CVs known at that time he must have realized the sharp drop of the number of CVs shortward of an orbital period of ~ 80 min, and not long after that went on explaining the physical significance of the minimum orbital period of CVs in the context of CV evolution (Paczynski 1981; Paczynski & Sienkiewicz 1981, 1983). This was probably the first direct application of the immediate precursor of Rcat to CV research.

Around 1981 personal storage accounts and screen editors on computers became finally available. Therefore, the data of the CV compilation were migrated to permanent electronic storage and editing. From that time on it not only became much easier to update the compilation but also to produce printed copies of it. As a consequence, so to speak as a test, soon after having gone electronic, the first and second edition of Rcat were produced and circulated in preprint form among a relatively large number (~ 200) of colleagues and libraries (Ritter 1982, 1983). The positive response to the catalogue then lead to the publication of the 3rd edition printed in a refereed journal (Ritter 1984). With data on CVs thus becoming widely available it took not long before another of the remarkable properties of the CV period distribution, i.e. the period gap, was addressed and an explanation for it in terms of CV evolution was given (Spruit & Ritter 1983; Rappaport, Vebunt & Joss 1983). Around 1987, when the 4th edition of Rcat (Ritter 1987) was published it was also realized, not least thanks to X-ray observations with EXOSAT, that the distribution of the orbital periods of the synchronized and non-synchronized magnetic CVs, i.e. of the AM Her stars and the intermediate polars, are significantly dif-

ferent and that this could be accounted for in terms of standard CV evolution by the fact that on average the mass transfer rate in CVs decreases with orbital period (Hameury et al. 1987). With the publication of the 5th edition of Rcat (Ritter 1990) another interesting property of the period distribution of CVs became apparent, namely the peculiar distribution of the orbital periods of AM Her stars below the period gap with 6 AM Her stars piling up within a very narrow period interval of only 2 min, the so-called period spike (see Fig. 1 in Ritter & Kolb 1992). In that paper we had also given a detailed analysis of the period spike and explained its position and width as a natural consequence of CV evolution in the context of the disrupted magnetic braking hypothesis. Although at that time the AM Her period spike was considered to be statistically highly significant and thus worth studying, now, more than 20 years later and with many more systems known, we must admit that there is no such spike and that we were just fooled by a statistical fluke.

With the 6th edition of the catalogue (Ritter & Kolb 1998) two major changes occurred. First, because the amount of work connected with updating the catalogue had increased so much that additional support, in particular for servicing the newly established catalogue websites, was needed, Ulrich Kolb (UK) stepped in, and so Rcat became RKcat. Since then UK has been mainly responsible for the maintenance of our websites. Second, beginning with the 6th edition the data became available in electronic form only, and no more than a brief introduction to the catalogue has appeared in print.

Finally since 2003, the 7th edition of RKcat (Ritter & Kolb 2003) has become available, the data again in electronic form only. The catalogue websites of the 7th edition are now updated regularly, currently every 6 months, and at the time of writing the 20th update (release 7.20) is available.

The development of Rcat/RKcat over the past 35 years is perhaps best illustrated by plotting the number of objects contained in the catalogue as a function of time, as is shown in Fig. 1. As is readily seen, the number of objects has been steadily and exponentially increasing with a growth rate of $\sim 9\%/year$ over the past 30 years!

3 Some Examples of Possible Future Applications of RKcat

Before going to discuss a few specific possibilities for future applications of RKcat, let us briefly make two rather general comments concerning RKcat and its future use.

- The first comment is a warning, namely that based on the criteria according to which objects

enter the catalogue, no subset of the objects listed in RKcat represents a statistically well-defined sample. One has to keep this in mind when e.g. comparing results of population synthesis calculations with distribution functions extracted from RKcat.

- The second general comment is that by now the number of objects contained in RKcat is larger by a factor 10 to 20 than it was 20 - 30 years ago, i.e. when the first applications of Rcat to problems of CV evolution were made. What this means is that now the contents of RKcat allows for statistically meaningful studies of the properties of various subsets of CVs, LMXBs or related objects, which because of too small numbers of objects had not been possible a decade or two ago.

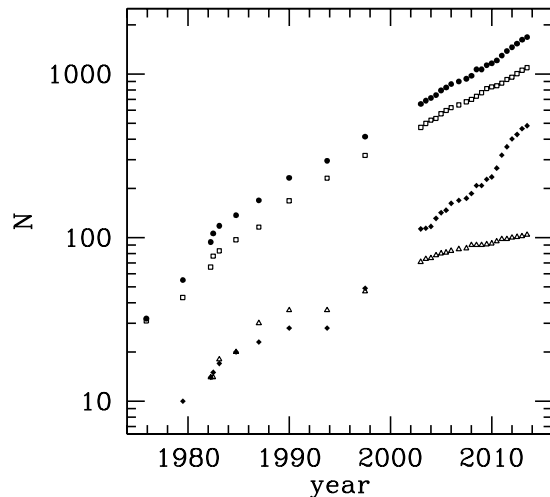


Figure 1: Number of CVs (open squares), LMXBs (open triangles), and related objects (filled diamonds), as well as the total number of objects (filled circles) contained in Rcat/RKcat and its precursors as a function of time.

Let us now turn to just a few specific possible future applications of RKcat.

1. It has long been known that the average orbital period of age zero post common envelope WD-RD binaries, i.e. of the binary central stars of planetary nebulae and systems where the WD is still so hot that it gives rise to a noticeable reflection effect on the companion, is systematically longer (by about a factor of 2) than the average orbital period of the remaining detached post common envelope WD-RD binaries. The qualitative explanation for this is that post common envelope binaries undergo orbital evolution as a consequence of

loss of orbital angular momentum. In that context it is important that now RKcat contains a relatively large number of detached WD-RD post common envelope binaries with reasonably accurately known binary parameters. Based on these data it should be possible to investigate the angular momentum loss of post common envelope WD-RD binaries in more detail, e.g. its dependence on properties of the RD, i.e. whether it is evolved or fully convective or not, and maybe even quantify it.

2. The period distribution of dwarf novae shows an undisputable dearth of systems in the period range $3^{\text{h}} \lesssim P_{\text{orb}} \lesssim 4^{\text{h}}$ which is not predicted by the standard CV evolutionary paradigm, i.e. the disrupted magnetic braking hypothesis, in combination with the disc instability model for dwarf nova outbursts. A satisfactory explanation for this phenomenon is so far lacking. In the framework of the disc instability model this could be accounted for only if the mass transfer rate is decreasing less strongly with orbital period than the critical mass transfer rate for dwarf nova outbursts as a CV evolves from longer to shorter orbital periods. This, in turn, implies that the angular momentum loss time scale must decrease with the orbital period, contrary to what standard prescriptions of magnetic braking, e.g. Verbunt & Zwaan (1981) or Mestel & Spruit (1983) predict. The ratio of the number of dwarf novae to nova-like systems as a function of orbital period, on the other hand, should allow for an empirical calibration of the angular momentum loss rate as a function of orbital period.
3. As the absence of a clear period gap in the period distribution of AM Her systems suggests, the strong magnetic field of the WD interferes with the loss of mass and angular momentum via a stellar wind from the companion star with the result that magnetic braking in magnetic CVs is significantly weaker than in non-magnetic CVs. Therefore, if below the period gap angular momentum loss via magnetic braking is comparable to that caused by gravitational radiation, as has been argued e.g. by Knigge, Patterson & Baraffe (2011), and if magnetic braking is also weaker in AM Her stars below the gap, one would expect that also the minimum period of AM Her stars is systematically shorter than that of non-magnetic systems. Therefore, by a careful examination of the period distributions of magnetic and non-magnetic CVs below the gap it should be possible to get more insight into the evolution of CVs below the gap.

Clearly, the above list of possible future applications of RKcat is not exhaustive. What we hope for is that our colleagues working with RKcat will come up with many more and even more ingenious applications of RKcat for the research in the field of compact binaries than we have just given.

4 The Future of RKcat

Apart from discussing future applications of RKcat we think that writing this paper provides us also with an excellent opportunity to briefly address the possible future of RKcat itself. In that context it is important to be aware of the following facts:

- The number of objects in RKcat has been growing exponentially at a steady rate of $\sim 9\%/yr$ over the past 30 years (see Fig. 1), and so has the amount of work that has been going into RKcat. And there is no reason to expect that this will be much different in the near future.
- Already now, servicing the catalogue data base is practically a full-time job for HR.
- HR is already several years beyond formal retirement age.

Taken these three points together it is obvious that *HR will definitely not be able to provide this service for many more years.*

If RKact or something akin to it should be continued beyond HR's definitive retirement from that job then it is clear that in view of the first two points above some changes in how this service is and in what should be provided are unavoidable. The all decisive question to the CV community then is: *Who is prepared to continue with RKcat and in which form?*

Anybody out there?

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DISCUSSION

ASHLEY PAGNOTTA: Regarding the future of RKcat, have you considered working with the AAVSO? Their VSX is not nicely curated like RKcat but is a possible future home.

HANS RITTER: Up to now I had not approached anybody or any organisation regarding the future of RKcat. This is actually the first time that I have spoken in public about that problem.

CHRISTIAN KNIGGE: Just a comment on the topics you suggested for further study, which I think are really interesting. Regarding P_{\min} for magnetic CVs, Boris Gaensicke, Retha Pretorius and I have all looked at this a bit and have *not* seen the expected difference to non-magnetic CVs. [Note added: I think this is mostly unpublished – the only relevant publication I am aware of is Pretorius, Knigge & Schwobe 2013, MNRAS, 432, 570, where Fig. 1 shows that the period minimum for magnetic CVs is consistent with that for all CVs, which are dominated by non-magnetic systems. But we don't really discuss that in the text.] Also, in Fig. 18 of Knigge, Baraffe & Patterson (2011) we plot the dwarf nova fraction versus P_{orb} and find that not only is it zero just above the gap, but going from shorter to longer orbital periods it declines monotonically *through* the gap, which is very surprising.