the simple guidelines will be that programmes of general interest written by others following these guidelines can be easily integrated. This opens up the possibility of sharing to a wide number of people. Perhaps the message from this workshop on following guidelines is: "Try it, you'll like." A corollary is: "So will your colleagues.".

Finally those present at this workshop felt that the success of these few days warranted continued meetings on this topic at roughly 6-month intervals. The group decided to baptize themselves as the "Working Group on Co-ordination of Astronomical Software", but did not consider drawing up any formal "terms of reference" to guide the further deliberations. Thus the future tasks of the Working Group are still to be defined. Suggestions are welcome.

P. Crane

Tentative Time-table of Council Sessions and Committee Meetings

The following dates and locations have been reserved for meetings of the ESO Council and Committees:

November 4	Scientific/Technical Committee, Garching
November 5	Finance Committee, Garching
November 6	Committee of Council, Garching
November 26-27	Council, Garching
December 2-4	Observing Programmes Committee, Garching

Cataclysmic Binaries – From the Point of View of Stellar Evolution

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Cataclysmic Binaries

Cataclysmic variables (CV's) is the common name of a subgroup of eruptive variables consisting of the classical novae, the dwarf novae, the recurrent novae and of the nova-like objects. Since Kraft's pioneering investigation about twenty years ago (Kraft, R. P.: 1973, *Adv. Astron. Astrophys.* **2**, 43) we know that probably all of the CV's are close binaries. However among the roughly 500 CV's known at present, only for about 50 objects has the binary nature been established by observations. Hereafter these objects will be referred to as cataclysmic binaries (CB's). From the histogram of their orbital periods, shown in Fig. 1, it is seen that CB's have extremely short orbital periods, typically only a few hours. Moreover the histogram shows a remarkable gap of orbital periods in the range between about 2 and 3 hours. This gap has been found to be statistically highly significant. Apparently CB's are divided into two subgroups, i. e. into the ultra-short-period CB's (hereafter USPCB's) with orbital periods $P \lesssim 2^h$ and into the longer-period CB's (hereafter LPCB's) with orbital periods $P \gtrsim 3^h$.

From the wealth of observational data gathered during the past twenty years (for details see the excellent review paper by B. Warner: 1976, IAU Symp. No. 73, p. 85) a standard model of CB's has been derived. Accordingly a CB consists of a white dwarf primary in orbit with a low-mass main-sequence secondary which fills its critical Roche volume (Fig. 2). Matter streaming from the secondary through the inner Lagrangian point L_1 falls into an accretion disk around the white dwarf. At the point where the matter coming from L_1 hits the disk a shock front is formed which is usually referred to as the hot spot (Fig. 2). The typical masses involved are roughly 1 $M_\odot$ for the white dwarf whereas the secondary's mass is approximately 0.1 $M_\odot$ times the orbital period in hours. The relation between the secondary's mass and the orbital period is a direct consequence of assuming the secondary to be a main-sequence star.

Are the Secondaries Evolved?

Knowing a CB's orbital period, the mass and the radius of the secondary can easily be computed if it is assumed to be a main-sequence star, i. e. that it is essentially unevolved. On the other hand deriving the secondary's mass and radius from observations without making this

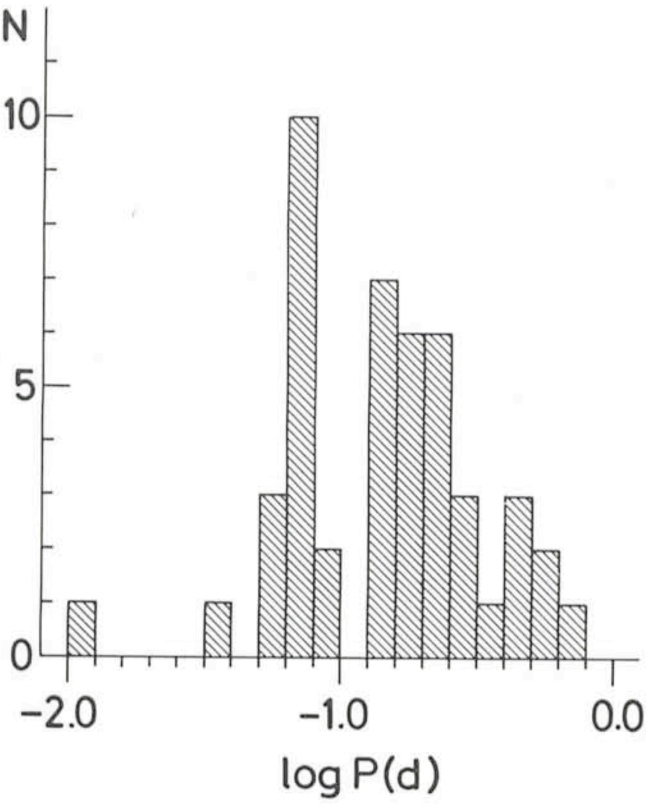

Fig. 1: *Histogram of the orbital periods of known cataclysmic binaries. Note the gap in orbital periods in the range $-1.0 \lesssim \log P$ (d) $\lesssim -0.9$, i. e. $2^h \lesssim P \lesssim 3^h$.*

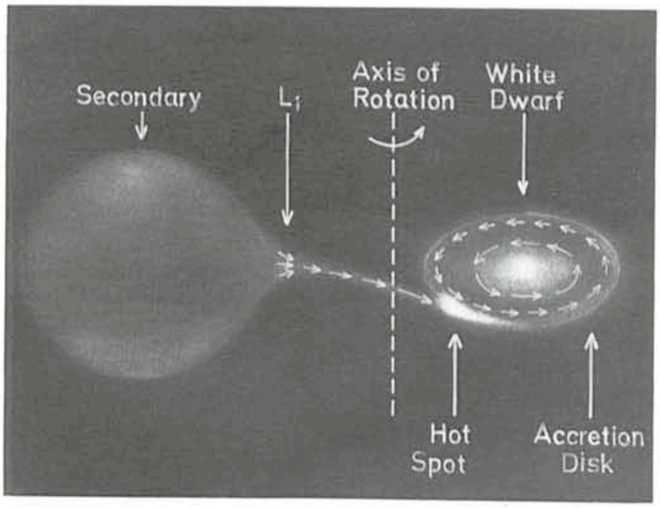

Fig. 2: *Model of a cataclysmic binary.*

assumption is very difficult. Nevertheless, it has been possible to make estimates in a few favourable cases, allowing a check of the main-sequence assumption to be made. For this, the secondary's position in the mass-radius diagram is compared with the theoretical mass-radius relation (M-R relation) of zero-age-main-sequence stars. This is shown in Fig. 3. Despite the considerable uncertainties in the observational data it is obvious that some of these secondaries lie significantly above the theoretical zero-age main sequence (ZAMS). This is usually interpreted as an evolutionary effect. Before starting to discuss whether this interpretation is correct it might be helpful to give first a short description of how CB's could have formed.

The Formation of CB's

In the framework of classical stellar evolution the formation of a massive white dwarf, as observed in CB's requires that the initial binary be a very wide system. This is because the primary needs a certain minimum volume in order to burn out a degenerate core of a given mass. Accordingly a typical progenitor of a CB would be a binary with an initial separation of $\sim 1{,}000\ R_\odot$, a total mass between $\sim 2\ M_\odot$ and $\sim 10\ M_\odot$ and an orbital period of a few years. By comparing the total mass and angular momentum of a typical progenitor with the corresponding values of a typical CB it becomes obvious that the progenitor has to lose almost all of its initial angular momentum and a substantial amount of mass during its evolution towards a CB. (Ritter, H.: 1976, *Monthly Notices Roy. Astron. Soc.*, **175**, 279). How does a binary achieve this? The current idea is that the Roche-overflow from the now red giant primary occurs on a very short time scale which in turn gives rise to the formation of a common envelope around the secondary and the primary's degenerate core. Due to its enormous moment of inertia that common envelope cannot maintain synchronous rotation with the binary inside it. As a consequence the binary transfers angular momentum via turbulent friction to the surrounding envelope. Thereby the binary speeds up faster than the envelope (Kepler's 3rd law!). Obviously such a situation is unstable. It forces the binary to spiral into the envelope by transferring most of its angular momentum to the outer shell in only a few thousand years (Meyer, F., Meyer-Hofmeister, E.: 1979, *Astron. Astrophys.*, **78**, 167).

Although details of how the binary manages to get out of such a desperate situation are not yet known, observations indicate that it does so by blowing off its common envelope. The result is an expanding shell which carries away some mass and almost all of the initial angular momentum. In its centre remains a very close binary consisting of the primary's degenerate core (to become a white dwarf) and of the secondary. To an observer the expanding shell would probably look very much like a Planetary nebula. In fact there are now two Planetary nebulae known (Abell 46 and Abell 63) in which the central stars have already many properties characteristic of CB's. Thus the above picture is strongly supported by observations of these two objects.

The Evolutionary Status of the Secondaries

(a) From a theoretical point of view: Some of the "evolved" secondaries in Fig. 3 are of very low mass, i. e. $M_2 \lesssim 0.5\ M_\odot$. If their present mass is still equal to their initial mass or if they have even accreted some mass during the common envelope phase, then these stars must be unevolved. This is because the evolutionary timescale for stars of such low masses exceeds the age of the universe. If on the other hand a secondary's initial mass was significantly higher than it is now and in addition was not too different from the primary's initial mass, say $1/2\ M_1 \lesssim M_2 \lesssim M_1$, then the secondary has already burnt a significant proportion of the hydrogen in its centre when the common envelope phase starts. Although such a secondary might still be very close to the main sequence before entering that phase, this will no longer be true if a considerable fraction of the star's hydrogen envelope is stripped off during the subsequent evolution. Removing

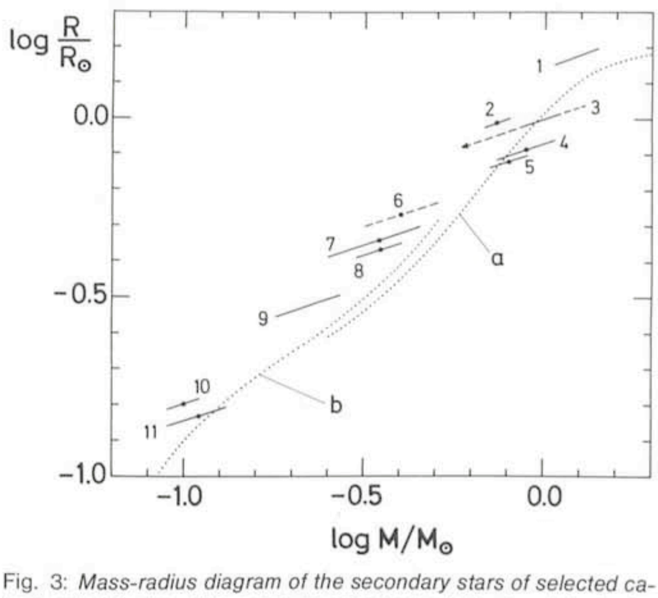

Fig. 3: *Mass-radius diagram of the secondary stars of selected cataclysmic binaries. The numbers refer to the following objects: 1 = BV Cen; 2 = AE Aqr; 3 = RU Peg; 4 = Em Cyg; 5 = SS Cyg; 6 = RW Tri; 7 = DQ Her; 8 = U Gem; 9 = AM Her; 10 = Z Cha, 11 = OY Car. For comparison two theoretical zero-age-main-sequence mass-radius relations are shown: (a) taken from Copeland, H., Jensen, J. O., Jorgensen, H. E.: 1970, Astron. Astrophys.,* **5**, *12; (b) taken from Grossmann, A. S., Hays, D., Graboske, H. C., Jr.: 1974, Astron. Astrophys.,* **30**, 95.

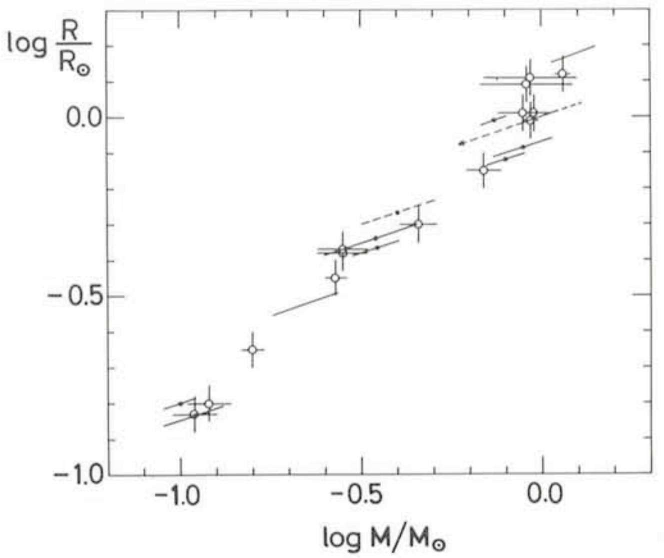

Fig. 4: *Comparison of the mass-radius diagram of the observed low-mass main sequence (open circles, data of visual binaries taken from Lacy, C. H.: 1977, Astrophys. J. Suppl.,* **34**, 479) with the mass-radius diagram of the secondary stars of cataclysmic binaries shown in Fig. 3.

all, or at least a substantial fraction, of the secondary's hydrogen envelope will result in a remnant which is considerably more evolved than a normally evolved star of the same mass and the same age. Depending on the exact chemical structure of such a remnant, the stripped star can stay either well above, or even below the main sequence. Since progenitors having secondaries of initially very low mass are less frequent than systems in which both stars are of comparable mass, the above suggested ablation of the secondary is likely to occur, at least in some cases. Thus a theoretician would not be much surprised if some of the secondaries of CB's were evolved.

(b) From the observer's point of view: In contrast to a theoretician, an observer would not compare the secondaries of CB's with theoretical computations but rather with other observations of stars which are known to be unevolved, e. g. with observations of visual binaries of low mass. The result of such a comparison is shown in Fig. 4. Obviously the secondaries of CB's and the observed low-mass main sequence, as defined by the visual binaries, match within the uncertainties. Thus the conclusion to be drawn from Fig. 4 is that the theoretical low-mass ZAMS is probably wrong rather than that the secondaries of CB's are evolved.

Consequences

As already mentioned above, the secondaries' masses can be determined from the orbital period by using a theoretical main sequence M-R relation. If, as has often been done, a M-R relation which is systematically incorrect is used, the resulting masses are also incorrect. The same holds for the masses of the white dwarfs, if they are derived from the secondaries' masses using an independently determined mass ratio. In fact, taking the observed rather than the theoretical M-R relation yields an interesting result in the case of the USPCB's. In contrast to previous results, it turns out that the corresponding white dwarfs are probably all of low mass, i. e. $M_1 \lesssim 0.5\,M_\odot$. This is interesting with regard to the physical significance of the observed period gap (Fig. 1).

The Period Gap

As just mentioned, the white dwarfs of USPCB's are probably all of low mass. On the other hand no low-mass white dwarfs have been found so far in any of the LPCB's. This gives rise to the speculation that the two subgroups of CB's may be distinguished in such a way that the USPCB's contain only (low-mass) helium white dwarfs ($M \lesssim 0.45\,M_\odot$) while the LPCB's contain only (massive) carbon-oxygen white dwarfs ($M \gtrsim 0.5...0.6\,M_\odot$). Thus the two groups would reflect two different modes of white dwarf formation. The USPCB's would accordingly have been formed in an evolution where the mass exchange started before the onset of the primary's central helium burning. On the other hand LPCB's would be the result of an evolution where mass exchange set in only after the central helium burning but still before the onset of central carbon burning (Ritter, H.: 1976, *Monthly Notices Roy. Astron. Soc.,* **175**, 279). The observed period gap would thus simply reflect the discontinuity in core masses connected with these two possibilities of mass exchange. However, the available observational data do not yet allow a reliable conclusion to be drawn.

Conclusions

The above discussion has shown the importance of reliable observational data of CB's for a better theoretical understanding of the history of these objects. New and better observations particularly aimed at determining the physical parameters of CB's, i. e. their masses and absolute dimensions, are urgently needed. It is with this end in view that the author, in cooperation with Dr. R. Schröder from the Hamburg Observatory, has started an observing programme on CB's. In a first step, two nights at the ESO 3.6 m telescope have been exclusively devoted to spectroscopy of the highly interesting CB Z Cha (see e. g. Ritter, H.: 1980, *Astron. Astrophys.,* **86**, 204). Thereby roughly 140 IDS-spectra have been obtained which are currently in the process of reduction. Results will be presented in a forthcoming communication.

NEWS AND NOTES

Micro-Workshop on Galactic Dynamics

Some members of the ESO Scientific Group and several distinguished guests participated in a "micro"-workshop on galactic dynamics at ESO Geneva, held on 5th and 6th May 1980.

The workshop concentrated on barred galaxies, and began with a lively discussion between Contopoulos and Lynden-Bell on the nature of stellar orbits in bars. They disagreed principally over the dynamical importance of highly elongated orbits in a weak bar. Sellwood presented results of several computer simulations in which bars formed due to instabilities in stellar disks, finding support in his models for some aspects of both theories. Lindblad had studied the response of stellar orbits to growing bars and found that spirals would result near the resonances of the pattern. Athanassoula reported an investigation of the global