CATALOGUES OF SPECTROSCOPIC BINARIES

Alan H. Batten

Dominion Astrophysical Observatory, Herzberg
Institute of Astrophysics.

There are two centres at which papers on spectroscopic binaries are filed and catalogues produced -- Toulouse, France and Victoria, B.C., Canada. The aims of these two are somewhat different. At Toulouse a running file of all references to spectroscopic binaries is kept, and many workers have found the comprehensive series of Catalogues Complémentaires (e.g. Pedoussaut and Carquillat 1973) very useful. At Victoria, on the other hand, we concentrate more specifically on spectroscopic determinations of orbital elements, and our catalogue of them was a direct successor of the five such catalogues published by the Lick Observatory. While the Toulouse catalogues are comprehensive, we at Victoria try to make a critical assessment of each orbit we include, and we regard this as one of the most important aspects of our catalogues. Such a critical catalogue obviously cannot be published as frequently as are the Catalogues Complémentaires, which, just as their name implies, are complementary to the Victoria work. There is no fixed interval between the publication of successive Lick-Victoria catalogues. The five from Lick appeared at a mean interval of about a decade, but the transfer to Victoria delayed the appearance of the Sixth Catalogue (Batten 1967) to almost twenty years after that of the Fifth (Moore and Neubauer 1948). After another decade, the Sixth Catalogue is out of date and out of print, and we are well advanced on the preparation of a Seventh, which we hope will appear in 1977. The Sixth Catalogue contained orbital elements for 737 spectroscopic binary systems. About 200 (or 25 per cent) new systems have now to be added, and about one per cent of those already in should be deleted. In addition, new orbital information is available for over 100 of the systems already in the Sixth Catalogue. As we plan to keep the files open until at least the end of 1976, these

C. Jaschek and G. A. Wilkins (eds.), Compilation, Critical Evaluation, and Distribution of Stellar Data. 141-145.

figures may well be exceeded when the Seventh Catalogue appears in print. The past decade has seen great activity in the field of spectroscopic binaries -- including the valuable work of Popper on accurate mass determinations from eclipsing binaries that show two spectra -- but nevertheless, nearly ninety years after the discovery of the first spectroscopic binary, still fewer than a thousand of these objects have known orbital elements.

The Victoria files have been only on handwritten cards, until now, and updating them has been slow. Mr. J.M. Fletcher is working on a punched-card system that will make updating the files fairly routine, and speed up the production of the new catalogue. This will be especially useful when the time comes to hand over the task of preparing these catalogues to someone else, or even to another institute. Mr. Patrick Mann is undertaking the laborious task of punching cards for all the existing data. The new catalogue will have much the same format as the existing one has, but we are planning to round off the values of the various orbital elements to specified numbers of significant figures. We regret rounding off rather than printing the values the original authors gave, but many observers quote more significant figures than are justified. On the other hand, rounding off will enable us to introduce an extra column on one page and to reinstate the values of $a \sin i$, which were not included in the Sixth Catalogue. We are trying to record as many magnitudes as possible on the photoelectric V system, and spectral types on the MK system, and this will make necessary some minor modifications in the presentation of these quantities. In this part of our work we shall be as much users of data compilations as producers.

We expect to use three cards for each set of orbital elements printed in the Catalogue. The first card identifies the star by H.D. number or other designation, coordinates for 1900, photoelectric V (or best available) magnitude -- together with the range of variation for eclipsing stars, and MK (or best available) spectral type. The second card contains the elements -- period in days, Julian Date of periastron (or other suitable epoch), longitude of periastron in degrees, eccentricity, semi-amplitude of velocity variation, systemic velocity (both in km s^{-1}), and an estimate of the quality of the orbit. The third card contains the bibliographical reference. Second and subsequent sets of orbital elements can be punched on two further cards each, but only the selected set of elements will be printed. Precession, the mass-function (or minimum masses), and the major semi-axis will be computed when a printed copy is made. We have already uncovered several errors in the Sixth Catalogue that arose from incorrect computation of these quantities (usually by the original author). On the other hand, we shall now have to make extra checks for typographical errors in the published values of the semi-amplitude.

We intend to continue with a five-point scale of quality ratings of the kind used in the Sixth Catalogue and applied in accordance with the criteria set out there, Ideally a quality rating should be objective in the sense that any two workers in the field would assign the same quality to a given orbit. In practice, objectivity of that kind is hard to attain and there will always be some disagreement about border-line cases. One might resolve this by delegating the assessment of quality to a committee of experts, but the judgements of a committee seldom inspire confidence, even (or, perhaps, especially) if it is composed of experts. The best way is probably to let one person, or a close group of colleagues do their best. The subjective opinions of those who know their job are not without objective value. One can try to quantify the various criteria that are used in reaching a quality assessment and weight the score for each criterion according to an agreed scheme. This is not always easy, however. A quantitative measure of the distribution of points along a velocity curve, for instance, is hard to devise; and the relative weights to be attached to this criterion and the dispersion of the spectrograph, say, are themselves a matter of subjective opinion. I still think the best way is to rely on one's "feel" for the quality of an orbit determination, and this cannot be quantified. Fortunately most sets of orbital elements classify themselves. Provisional or preliminary solutions are automatically classed d or e, as are many determinations made as a result of survey programmes in which full attention cannot be given to the achievement of the optimum distribution of observations. There are also some systems (e.g. U Cephei) in which the intrinsic uncertainties are so great that no matter how good or numerous the observations may be, only poor-quality orbital elements can be obtained. On the other hand, systems observed several times are bound to be classed as a or b unless independent determinations disagree strongly. Average determinations of orbital elements, which is what most of the rest are, belong in class c.

Quantities like orbital elements are not observed directly, but deduced from observations. Sometimes later investigators will reduce the data again in their own way, and present the maker of catalogues with two somewhat different sets of orbital elements based on exactly the same observations. It is difficult to know which set to choose for the catalogue. Our aim is always to list the best determination of orbital elements. Obviously those who recalculate the elements usually believe they have effected an improvement, otherwise they would not have undertaken the labour of calculation. It is not, however, always clear that they are right. Lucy and Sweeney (1971) recomputed orbital elements for many of the binaries in the Sixth Catalogue. They were interested in the reality of small eccentricities, and argued that many binaries listed as having slightly elliptical orbits had, instead, orbits that on the presently available evidence could not be distinguished from circular ones. They devised a criterion for testing the reality of a calculated eccentricity and, using it, rejected those obtained for many binaries. They derived new orbital elements for these systems, assuming the orbits to be circular, and maintain that these new values should be adopted. Their method of computation is uniform (although the observations themselves are heterogeneous) and it is tempting to make wholesale use of their results. There are, however, both ethical and scientific reasons for hesitating to do so. The ethical one was summed up by Moore and Neubauer (1948) who said that the original investigator "is entitled to the credit because of his greater contribution". Although credit is supposed to be of secondary importance to a scientist, his standing is often measured, these days, by the number of papers he publishes, or even the number of times they are cited. The compiler of a catalogue ought not to ignore that fact. The scientific reason is the question whether or not the elements obtained by Lucy and Sweeney are always improvements over the original values. While those investigators are certainly right to maintain that many orbits of small eccentricity are indistinguishable from circular ones, it does not necessarily follow that the eccentricities deduced should be ignored. If the observational errors obey the normal law, the statement that $e = 0.04$ with a standard deviation of 0.02 has the precise meaning that e is twice as likely to lie between 0.02 and 0.06 as to lie outside that range. This is different from saying that the orbit is circular. It is true, as Lucy and Sweeney point out, that the light curves of many eclipsing binaries show the orbits to be circular although the velocity curves correspond to elliptical orbits. These eccentricities are spurious in the sense that they do not correspond to the geometrical reality of the orbit, but they may nonetheless measure a real distortion of the velocity curve. Spurious eccentricities can arise from accidental errors of observation or from systematic ones. It is often difficult to know which kind of error is acting in a specific case, and we hesitate to suppress the information that may be conveyed by a small eccentricity, even though we recognize that, naively interpreted, that information is often misleading. We have adopted the results of Lucy and Sweeney when they seemed to us to be real improvements over the original result, but otherwise have relegated them to the notes at the back of the Catalogue. The problem is discussed at length here because it is, perhaps, typical of problems that arise in this sort of work and merits some general consideration.

We shall continue to provide notes on virtually every system in the catalogue as such notes seem to us an essential part of any critical catalogue of the kind we have been discussing. Since detailed notes lend themselves less readily to presentation on punched cards than do the numerical data, the notes perhaps

https://doi.org/10.1017/S0252921100052982 Published online by Cambridge University Press

form the principal justification for issuing the catalogue in book form. The cost of the *Sixth Catalogue* (reckoned only from the printing costs) was about $10 per copy: that of the *Seventh* will undoubtedly be appreciably higher. We have to balance these costs against the convenience of a catalogue in printed book form. For the *Seventh Catalogue* the balance will probably be in favour of a publication in essentially the same format as that used for the *Sixth Catalogue*. If present trends continue, however, it may be necessary to look for cheaper ways of producing further catalogues in the series; perhaps the solution is to provide supplements on tape or punched cards.

References

Batten, A.H. 1967 *Publ. Dom. Astrophys. Obs.* 13, 119.
Lucy, L.B. and Sweeney, M.A. 1971, *Astr. J.* 76, 544.
Moore, J.H. and Neubauer, F.J. 1948, *Lick Obs. Bull.* 20, 1.
Pedoussaut, A. and Carquillat, J.-M. 1973, *Astron. Astrophys. Suppl.* 10, 105.

https://doi.org/10.1017/S0252921100052982 Published online by Cambridge University Press