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Used to describe both binary systems and optical doubles, the term 'double star' has been familiar to astronomers since the seventeenth century. This book, first published in 1879, outlines the history of their study, and describes the methods and equipment needed in order to observe the fascinating phenomenon. Written for non-specialists by Fellows of the Royal Society Edward Crossley (1841–1904), Joseph Gledhill (1837–1906) and James M. Wilson (1836–1931), the catalogue of over 1,200 double stars appears beside detailed notes and does not assume mathematical expertise. Also offered are a fully worked example of how to find the orbit of a binary star, and illustrations of telescopes, observatories, and even custom-made observation chairs. This reissue includes the supplement with corrections and notes published in 1880. A standard reference text in the late nineteenth century, the work remains a resources for students and scholars of the history of astronomy.

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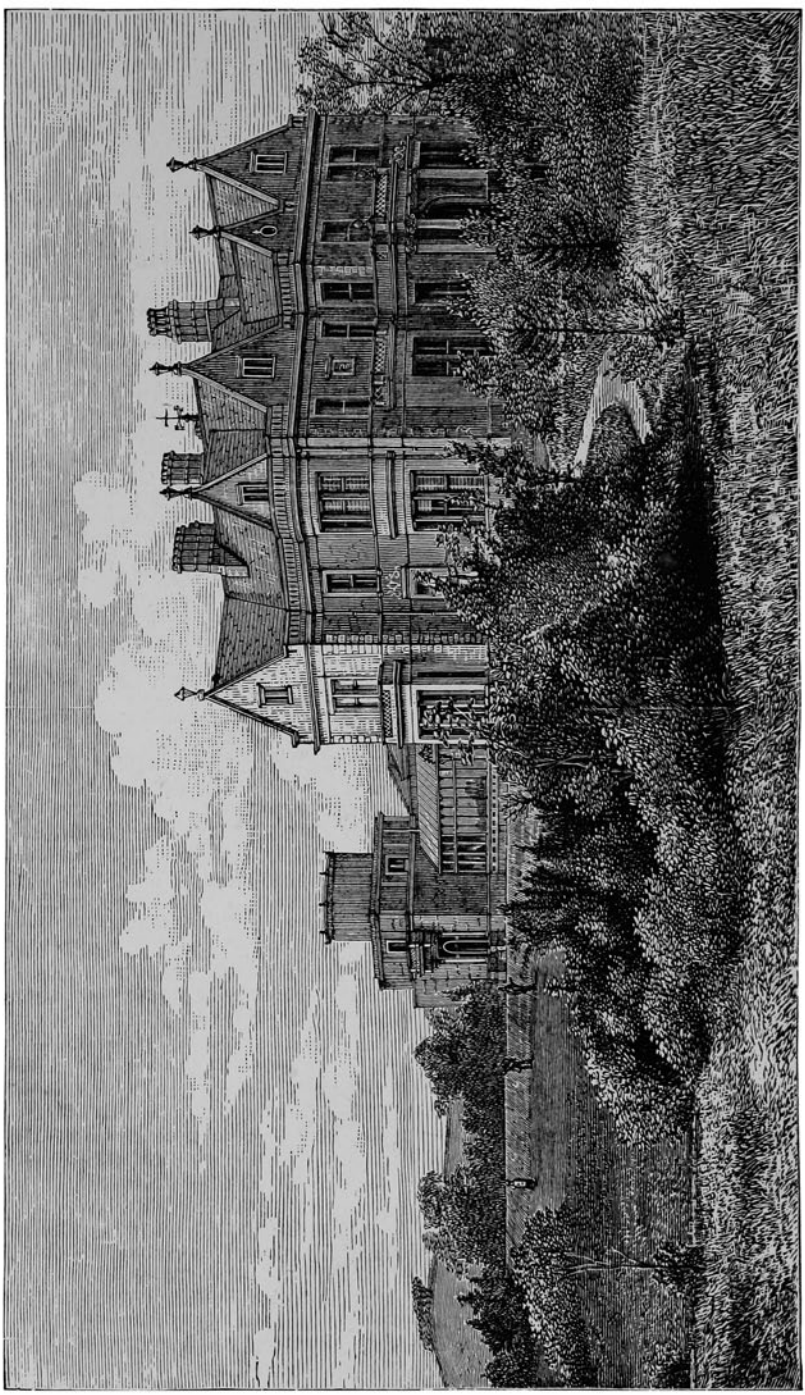

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A

HANDBOOK

OF

DOUBLE STARS,

WITH A

CATALOGUE OF TWELVE HUNDRED DOUBLE STARS AND EXTENSIVE LISTS OF MEASURES.

With additional Notes bringing the Measures up to 1879.

FOR THE USE OF AMATEURS.

BY

EDWD. CROSSLEY, F.R.A.S.; JOSEPH GLEDHILL, F.R.A.S., AND JAMES M. WILSON, M.A., F.R.A.S.

"The subject has already proved so extensive, and still promises so rich a harvest to those who are inclined to be diligent in the pursuit, that I cannot help inviting every lover of astronomy to join with me in observations that must inevitably lead to new discoveries."—SIR WM. HERSCHEL.

"Stellæ fixæ, quæ in cœlo conspiciuntur, sunt aut soles simplices, qualis sol noster, aut systemata ex binis vel interdum pluribus solibus peculiari nexu physico inter se junctis composita. Stellarum simplicium numerus est quidem major, at vero non nisi ter vel fortasse bis tantum major quam systematum compositorum."—Σ.

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PREFACE.

THIS work has arisen out of our own wants as students of that branch of astronomy which deals with Double Stars, and it is on this account that we think it will be useful to others who are occupied in the same work. There does not exist any book which gives information sufficiently detailed to be of value to any one who seriously takes up this study. He must hunt through scores and hundreds of volumes if he wishes to get an accurate and complete list of the previous measures of any particular double star. These measures are scattered up and down the astronomical periodicals of all nations. If he wishes to know with what instruments, with what apertures, and what micrometers these measures were taken, a fresh research awaits him. And if he proceeds to attempt an orbit, he will fail, unless he is a tolerably expert mathematician, from want of sufficient guidance and detail in the various mathematical papers and pamphlets that have been devoted to this subject.

This branch of astronomy is peculiarly suitable to amateurs. It does not require long previous training; it does not demand unintermittent and severe work, nor the resources of a permanent observatory and staff. All it needs is a good telescope, a good eye, some patience, much conscientiousness, and—more than all—such an amount of guidance and co-

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operation as shall convince the amateur that his work is not useless, but that he is really contributing something, however small, to astronomical knowledge. And the construction of double-star orbits has always had a fascination for amateurs from the days of Admiral Smyth and γ Virginis to the present time; and it is perhaps the only branch of mathematical astronomy which is quite within the range of unprofessional mathematicians.

We venture to hope that this book will be of use in guiding amateurs in their work,—in pointing out what stars are of especial interest, what stars have had few or conflicting measures taken of them, at what times observations of certain stars are especially needful, and what stars have been so frequently and satisfactorily measured that for the present they need no attention. This sort of information has become a necessity owing to the extension of the subject and the number of observers. The Herschels, the elder Struve, and Mädler, might with equal advantage measure every double star they saw; but later observers must select their objects if they do not wish much of their work to be wasted. And so we find that Otto Struve, and Dawes, and Secchi, and others, have chosen stars that were certainly or probably of interest as subjects for their own work.

There has probably been no time in which so much work has been done in measuring double stars as during the last six or seven years. They have witnessed Burnham's lists of new double stars, which testify so highly to his telescope, his eye, his climate, and his industry; Otto Struve's two important volumes on his father's and his own double stars; Dembowski's lists in the *Astronomische Nachrichten*; Dunér's valuable volume of observations made at Lund; in America,

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the work of Hall, Stone, etc.; and in our own country, that of Knott and others.

The recalculation of orbits, also, is occupying much attention, both among foreign astronomers and at home; and every year will enable this to be done with greater accuracy, and to be attempted for a greater number of stars.

This work, then, consists of four parts. The first part is historical, and descriptive of instruments and methods; the second is mathematical; the third part contains lists of measures of the most interesting double and multiple stars, with historical notes on those which are of special interest; the fourth part is bibliographical.

In Part I., Chapter I. contains a historical introduction by Mr. Gledhill. Chapter II. is on the equatorial and the observatory, by Mr. Crossley; Chapter III. is an account of the equatorials which have been used by double-star observers, by Mr. Gledhill; Chapter IV. on micrometers, by Mr. Crossley; and Chapter V. on methods of observing, by Mr. Gledhill.

In Part II., Chapters I. and II. give a detailed account, with a fully worked example, of determining an orbit and an ephemeris by a purely graphical construction, founded on Herschel's and Thiele's methods, with some fresh extensions, by Mr. Wilson. Dr. Doberck, who has had very great experience in double-star calculations, has contributed Chapter III., giving an example of the application of analysis to a double-star orbit already approximately known by graphical methods, and shows how greater accuracy may be obtained by it; and Mr. Wilson gives Chapter IV. on the relative rectilinear motion of double stars; Chapter V. on the effects of proper motion and parallactic motion; and Chapter VI. on

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the mode of combining observations, and determining their weight.

Part III. contains a catalogue of double stars selected as of special interest, with a list of all accessible measures, and notes, etc., by Mr. Gledhill.

Finally, Part IV. contains the bibliography of the whole subject, and is due to Mr. Gledhill.

We may, perhaps, venture to say a word or two on the importance of this part of astronomy. It can scarcely fail to happen that accurate measures of double stars, especially when combined with a study of proper motion, will give in the future some sounder knowledge of the structure of the heavens. The calculation of double-star orbits, and the comparison of observed and calculated places, will bring out not only errors in the observations or of the computer, but the existence of forces that had been unsuspected. Resisting media and the laws of their condensation, unseen companions, and possibly new laws of force, may be discovered. And these investigations must throw light on the origin of these double and multiple systems, and thus indirectly on our own solar system.

Again; if the difference of the linear velocities of the components of a binary system can be directly ascertained by the spectroscope, this fact, combined with a good knowledge of the orbit and of the period of revolution, and of the apparent mean angular distance, will lead to a knowledge of the parallax of the system, and therefore also to a knowledge of their mass.

At present we cannot see the significance of all that has been discovered: for example, the fact that the orbits hitherto computed are all elliptical, and very nearly all of

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large eccentricity, is too uniform to be an accident, and yet it is too isolated a fact to build theories on with safety. It does, however, seem to prove that these are genuine systems *ab initio*, and are not formed by the fortuitous approximation of single stars.

Nor, again, have we found the reason why the type of triple stars, such as μ Herculis, γ Andromedæ, ζ Cancri, μ Boötis—a bright primary and a faint binary companion—should be so common. When, further, we come to examine into the colours of binaries, we cannot yet see to what previous stage in their history is owing the absence of red stars in these systems, and the frequency of other colours which in their turn are rare in solitary stars. Spectroscopic observation will doubtless add some information on the point of fact, but will only remove the difficulty one stage further on. Again, the phenomenon of *variable* and *temporary* stars has always suggested the notion of a revolving dark companion. This may need further examination, and light may be thrown on the subject from tracing the gradual development of binary systems. In a word, the further study of binaries will help our successors to know what is the development-order of star systems and planetary systems.

The present work, therefore, is intended to facilitate the labours of future students of sidereal astronomy, by supplying the materials for the study of double stars in a convenient form, and as complete (so far as it is intended to go) as our utmost pains could make it.

The distribution of double stars has not been investigated, and it is perhaps at present premature to attempt it until more is known about them in both hemispheres; but there are already plain indications that it is not entirely fortuitous.

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A knowledge of their distribution will scarcely fail to throw light on the great problem of the structure of the sidereal universe.

Similarly, it will be observed that we devote no chapters to the variability of colour or intensity in the components of double stars. We have been debarred from this branch of the subject by want of time, by the badness of our climate, and by the unsuitability of our instruments. It is to be hoped that this work will be taken up by some one else. Small telescopes, and especially small reflectors, are well suited to the examination of colour; but if possible a careful spectroscopic examination of each star should be made. We have, however, provided in the bibliographical part of the book some references to the chief works and papers on this subject.

We therefore commend this study to amateurs. They may be encouraged by the thought that, with few exceptions, all the great workers in this branch of astronomy have been amateurs; and be stimulated to exertion by the thought that observations made now will certainly be of value to their successors. The stars will not stand still. How can we be idle, and let slip the time for observations, which, if not made now, can never be made hereafter?

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September, 1879.

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ERRATA.

Page 154. No 100. The Dec. should be 28° 55′; see also No. 100 in the "Measures," p. 202.

154. No. 116. For the magnitudes, read 6, 7.

163. No. 524. The Dec. is 2° 15′.

163. Line 1, read, ξ Scorpii.

165. The Ref. No. 623 is given twice; the second should be 624.

275. The formulæ given are Doberck's modified by Dunér.
Doberck's formulæ are
$P = 81°{\cdot}25 - 0°{\cdot}567\ (t - 1850) + 0°{\cdot}0057\ (t - 1850)^2$.
$\Delta = 2''{\cdot}47 + 0''{\cdot}013\ (t - 1850)$.

373. W. and S.'s positions of δ Cygni should be 339·1, 335·8. And in the diagram, 1875 should be at the other end of the curve.

406. Line 34. The date of De.'s measure (38°·9, 0″·85) is 1867·9.

407. Line 22. The measure of h. 4649 in 1837·5 was also by H_2.

The plate facing p. 248, illustrating the looped path of ζ Cancri $\left(\frac{A + B}{2}\right.$ and $\left.C\right)$, is taken from the *Observations de Foulkova*, vol. ix.

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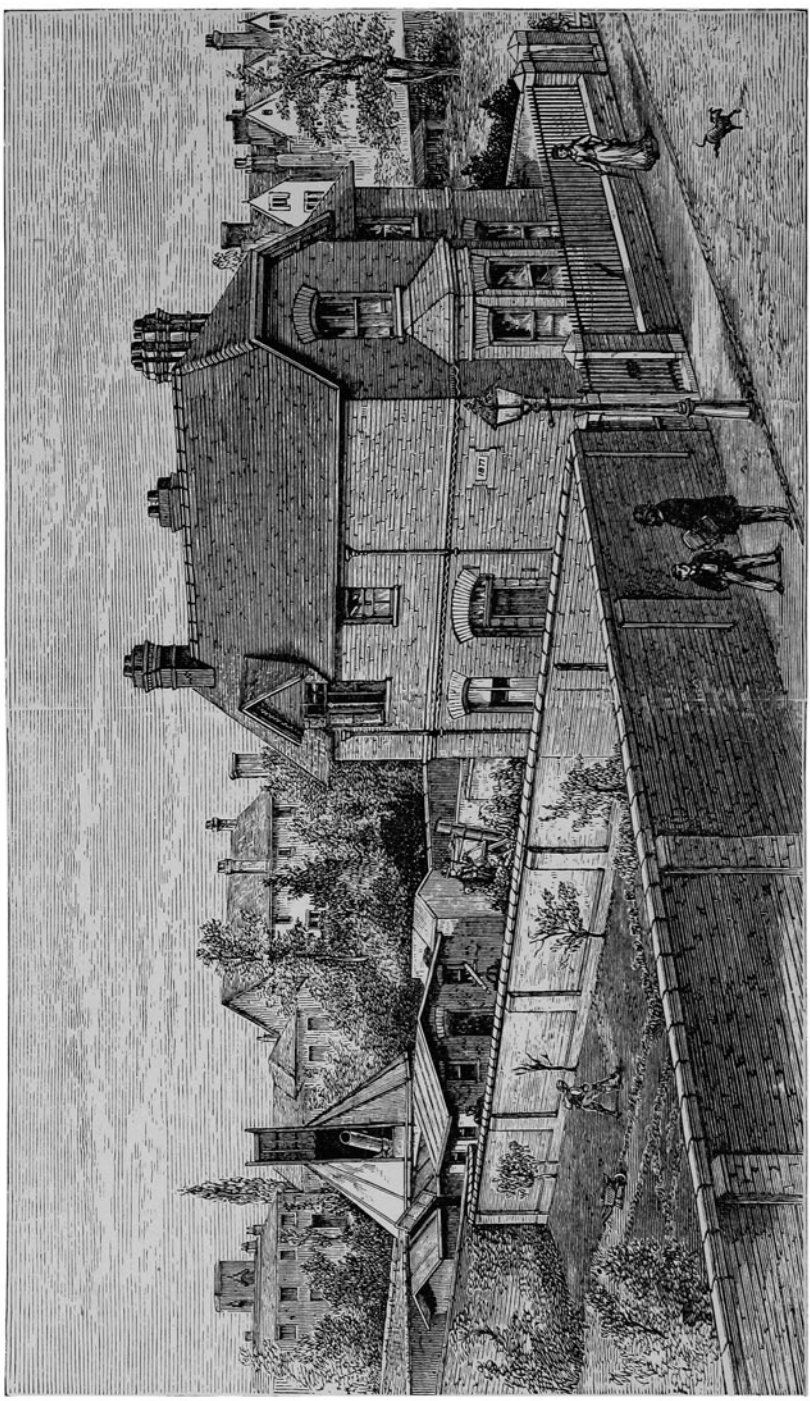

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