Preface

Double stars are the rule, rather than the exception, in the solar neighbourhood and probably beyond. Current theories of star formation point to multiple stars or stars and planets as the preferential outcome of gravitating protostellar material. Stellar pairs can be detected at many wavelengths from X-rays, where modern satellites can resolve the two brightest components of Castor (separation 3.8 arcsec) to the radio where the precision of long baseline interferometry can also see the 4 milli-arcsecond (mas) "wobble" in the 2.87-day eclipsing system of Algol and can distinguish which of the two stars is emitting the radio waves. Optical techniques have also constantly improved—array observations now regularly give positional accuracies of better than 1 mas for bright binaries such as beta Lyrae.

Binary stars come in a wide range of orbital sizes, periods, and masses – from the multiple system alpha + KU Lib where the stars are separated by almost 1 parsec and whose motion is barely perceptible, through the spectroscopic binaries with periods of weeks, down to exotic pairs like double white dwarf contact systems with periods of 5 min. From young O-star binaries like NGC 3603 A1 in the Large Magellanic Cloud containing two extremely bright and hot stars, of 116 and 89 solar masses, down to the wide system known as Source 11 in the Ophiuchus star-forming region 16222-2405. In this case the two M9 dwarfs both have masses thought to be less than 0.02 solar masses although the uncertainty is around 50% in each case.

In this volume we are concentrating on only one aspect, the visual double stars, which we can define as those pairs which can be seen or imaged in a telescope of moderate aperture. In Fig. 1 this corresponds to the range of separations from about $0''.2$ upwards. Modern, large telescopes can reach $0''.02$ whilst the ground-based interferometer arrays can reach $0''.002$. This sort of resolution can also be reached with the ordinary telescope, if lunar occultations are considered. It also offers the observer a chance to make a new discovery, and details can be found in the chapter by Graham Appleby (Chap. 21).

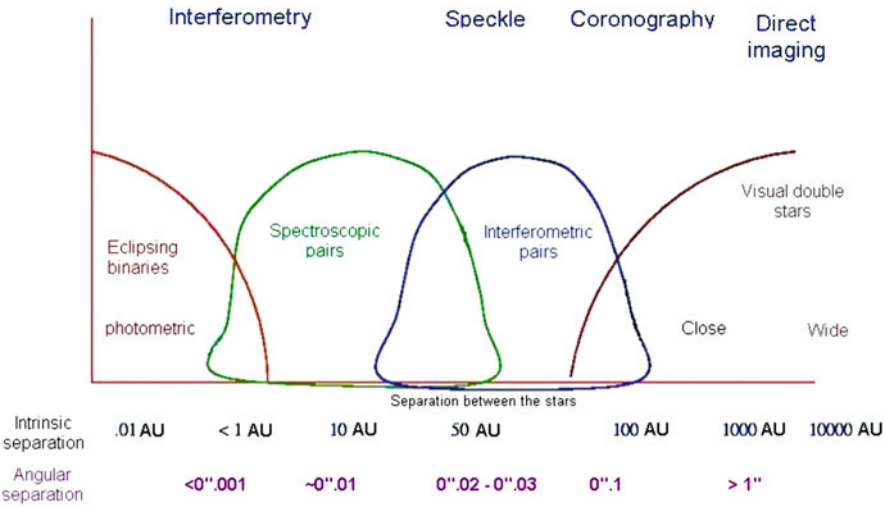

Fig. 1 The categories of double and multiple stars

The classic image of the double-star observer as a professional scientist with a large refractor and a brass filar micrometer is no longer valid. Researchers cannot afford to spend a lifetime measuring a large number of pairs in order to get a few dozen orbits. The high-precision astrometric satellites, ground-based interferometer arrays, and infrared speckle interferometry have all helped, respectively, to discover large numbers of new pairs, push direct detection into the spectroscopic regime with measurement of binaries with periods of a few days, and to probe the near and mid-infrared where faint red and brown dwarf companions and, ultimately, planets appear. This has left a large number of wide, faint pairs which are underobserved.

There has been a common perception that double star observing either is not very interesting or does not afford any opportunities for useful work. The aim of this book is to dispel these views and indicate where observers might usefully direct their efforts. At the basic level, we give advice about how to observe them with binoculars and small telescopes. At a more serious level, chapters about micrometers, CCD cameras, DSLR cameras, and other techniques have been included. For those who do not wish to spend several hundred pounds on a filar micrometer, assuming that you can find one, the graticule eyepieces such as the Celestron Micro Guide, as described by E.T.H. Teague in Chap. 12, are available for catadioptric telescopes and can be used effectively for relative position measurement of wider pairs. For those who find observing too taxing, astrometry of faint pairs can be done by examination of some of the huge catalogues produced from the various Schmidt surveys, and in Chap. 19 Rafael Caballero takes us through the means and facilities.

Clearly for the observer, the role of the telescope is very important. For casual viewing any optical aid can give reasonable views of wide and bright double stars.

I spent several years accumulating visual estimates of colour, magnitudes, and relative positions of more than 1,000 pairs using a 21-cm reflector using Webb's Celestial Objects for Common Telescopes (Volume II) and Norton's Star Atlas (15th edition, 1964). Even in this copy of Norton many of the measures given were more than 30 years old and it was this that sparked an interest in obtaining a micrometer to bring them up to date.

For those who wish to enjoy the glory and colours of double stars, this version retains the advice from Michael Ropelewski on double stars accessible to ordinary binoculars (Chap. 3), and with this edition we have a welcome additional chapter by Jeremy Perez on how to sketch them (Chap. 4).

On the whole, equatorially mounted telescopes are almost a necessity and although Dobsonian telescopes can give fine views of double stars, using them for measurement is not straightforward. Potential users should look at Chap. 25 where Michael Greaney shows how to calculate position angle in situations where the field rotates. Whilst the grating micrometer (described by Andreas Maurer in Chap. 14) is relatively insensitive to the lack of an RA drive the field rotation is an added problem.

Resolution is ultimately dependent on aperture, and although many of the most interesting binaries are significantly closer than 1 arcsec, the aperture available to today's observers is no longer limited to the small sizes that were common about 30 or 40 years ago when the 12.5-in. reflector was the exception rather than the rule. These days no one is surprised to see amateur observers sporting 30-, 40- or even 50-in. telescopes and for those who thought that refractors were the required telescope for double-star observing then Christopher Taylor has other ideas (Chap. 11).

In the last 20 years the CCD camera has become a dominant force in observational astronomy. As both a positional and photometric detector it has excellent applications in the observation of double stars and these will be discussed later by Bob Buchheim (Chap. 15).

Whilst filar micrometers were available commercially at the time of the first edition, they are now more difficult to obtain. See the references to Chap. 13 for possible commercial contacts. The main advantage is that they are effective up to the resolving limit of the telescope and do not require software to produce results. Bob Argyle describes how to use a modern instrument in Chap. 13. Those with the larger apertures, however, should consider the speckle interferometer as an alternative to the micrometer. With atmospheric effects becoming more significant with telescope size, the speckle camera can punch through the turbulence and produce diffraction limit imaging. In Chap. 18 Nils Turner shows how this can be achieved at relatively low cost. An alternative technique, lucky imaging, takes advantages of moments of quiet air to capture good quality images in short exposures and is described by Rainer Anton in Chap. 16.

The availability of inexpensive and yet powerful personal computers has brought several other aspects of double-star astronomy within reach. The latest static version of the United States Naval Observatory double-star catalogue, WDS 2006.5, is now available on CD-ROM (the regularly updated WDS catalogue is available online only and incremental files can be downloaded to update the static version of the

catalogue). It is no longer necessary to measure the bright pairs which appear in the popular observing guides. Using the WDS the more neglected pairs can be selected for measurement and charting software makes finding even the most obscure pair much easier. The USNO have placed on their website several lists of neglected double stars which they would like observers either to confirm as double or to make new measures. In Chap. 26 Owen Brazell has updated his survey of the various software packages including charting software which are available to help the double-star and deep-sky observer.

Orbital computation, once the province of specialists, can now be done by anyone but it is not to be taken lightly. Even if all the measures of a particular system can be rounded up it still requires an appreciation of the quality of the observations and the existence of systematic errors. How do you combine measures by Struve in 1828 with those by van Biesbroeck in 1935 and speckle measures made in 1990? Perhaps most importantly is a new orbit necessary and is yours better than any others? Andreas Alzner has contributed Chaps. 7 and 8 on this important topic.

Since the appearance of the first edition of this considerable progress has been made in re-observing many wide and neglected systems, thanks to the creation of a target list by Brian Mason at USNO. The editor remains of the opinion that regular and accurate measurement of the longer period visual binaries is invaluable in helping to refine their orbits. The new binaries found by Hipparcos are still underobserved and although they are, on the whole, difficult objects, a 40-cm telescope and lucky imaging camera could be employed usefully to make much-needed observations of them. The next big advance—the GAIA mission—will investigate a separation and magnitude regime which may well remain beyond the ability of the earth-based amateur to investigate.

Amateur participation in double-star astronomy has increased substantially in the last 10 years partly due to the better availability of good quality telescopes and detectors. A brief summary of some of the current activity is given in Chap. 23. Another source of fine optics can be found in older academic institutions, particularly in the USA, where there are some fine refractors, some of considerable aperture and power, which could be used again for a purpose for which some of them were designed.

Finally, there is still an imbalance in the two hemispheres with most of the effort being concentrated on the north. It is only recently that bright pairs such as delta Velorum and beta Phoenicis have received more attention both observationally and analytically. Many more southern objects such as the Rossiter pairs could be examined again with advantage, and the southern Hipparcos (HDS) and (TDT) double stars though difficult will repay continued observation.

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