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Massive Binary Stars as a Probe of Massive Star Formation  
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ICCD Speckle Observations of Binary Stars XXII  
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Interacting Binary Stars  
The Origins, Evolution, and Destinies of Binary Stars in Clusters  
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The Brightest Binaries

The Importance of Binaries in the Formation and Evolution of Planetary Nebulae

An Introduction to Close Binary Stars

Double Stars

Investigations of Binary Stars

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## **CASTANEDA SAWYER**

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### Massive Binary Stars as a Probe of Massive Star Formation

Springer Science & Business Media

The evolution of galaxies is governed mainly by the evolution of massive stars whereas the evolution of a massive star depends primarily on its mass, chemical composition and on whether or not the star is a Single object or a binary component. To study the evolution of galaxies, it is therefore essential to know how stellar masses are distributed at birth, how many stars are formed in binaries, and what the mass ratio and orbital period distribution of binaries look like. Massive stars are intrinsically the brightest stars, so that it may be possible to discover their properties in distant groups provided that large telescopes can be used for basic stellar observations. However, until now the observations of massive stars have been reasonably complete only for a small region of our own Galaxy (~ 3 kpc from the Sun). One hopes that the conclusions resulting from these observations hold for the whole Galaxy, for the whole cosmos. With 'The Brightest Stars' of De Jager (1980) in mind, the present monograph is an addendum and an update in which we discuss the observations of 'The Brightest Binaries' in the framework of stellar evolution. A small or intermediate mass star close to the Sun may look brighter than a massive one far away. However, within volume limited star samples, the massive stars are on average also the brightest ones. In the present monograph (similarly as in the work of De Jager), bright means massive. The book consists of four main chapters.

*Binary Stars: Selected Topics on Observations and Physical Processes* Springer Science & Business Media

In the two decades since the development of the first eclipsing-binary modeling code, new analytic techniques and the

availability of powerful, sometimes dedicated computing facilities have made possible vastly improved determinations of fundamental and even transient stellar parameters. The scale of these developments, of course, raises questions about modeling tools, techniques, and philosophies, such as: Who will maintain and upgrade the codes? Will the codes be open to improvement by outsiders, and if so, how? And, indeed, what should be the goals of a modeling program? Such questions had not been aired for a long time and, for this reason alone, deserved to be discussed in as general a forum as the community provides. This volume contains material presented by Commission 42 (Close Binary Stars) during the International Astronomical Union's XXI General Assembly in Argentina, July 1991, and during IAU Colloquium 151, Cordoba, Argentina, August 1991. The techniques discussed include simulations of stellar bright and dark spots, streams, partial and complete stellar disks, prominences, and other features characterizing active stars; modeling of polarization parameters; models that use radial velocities as well as line profile simulations to model velocity field variation across stellar disks; the weighted effects of brightness asymmetries; and models for translucent eclipsing agents such as stellar winds.

*The Impact of Binary Stars on Stellar Evolution* Springer Science & Business Media

Since the 1970s symposia or colloquia devoted to recent research on close binaries have been held around the world almost annually. At meetings of the General Assembly of the International Astronomical Union this topic has also been discussed in detail at presentations in various commission meetings and also as invited talks by leading astronomers in the field. In recent years, fundamental changes have taken place in the study of close binaries due to the improvements in observational techniques, extension of observations from X-ray to radio regions of the electromagnetic spectrum, and advances in theoretical studies. For more than a decade, a group of

astronomers at Ege University Observatory has been concentrating on active close binaries with particular emphasis on the behaviour of the light curves of chromospherically active systems. Thus, we decided to organize an international meeting in Western Anatolia, where this part of Turkey had been the cradle for great developments in science during antiquity. KUljadasi, located only minutes away from Ephesus, one of the seven wonders of the world, was selected to be the meeting site. Close binary systems constitute a very rich source of information about the physical properties of the component stars. Some systems are eclipsing variables, where periodic recurrences of eclipses are observed as comparatively brief decreases in the total brightness of the binary system. Precise methods of photometric observations make it possible to obtain the light variations of these systems because of eclipses and other phenomena.

**Dynamics of Close Binary Systems** Springer Science & Business Media

An advanced review of how binary stars affect stellar evolution, presenting results from state-of-the art models and recent observations.

**Planets in Binary Star Systems** Springer

Symposium No. 88 of the International Astronomical Union was devoted to a comprehensive review of all types of close binary stars. The nine sessions were organized according to the type of the objects to be discussed. We have preserved this system, but assembled twelve papers of a more general character (reviews and surveys) into a special chapter placed at the beginning of this book. We would like to remind the reader that the Symposium was preceded by the IAU Colloquium No. 53 on White Dwarfs and Variable Degenerate Stars, and that the sessions on Cataclysmic Variables and related topics at the two meetings supplemented each other. The discussion in Toronto was carefully recorded by Mr. Robert Gauthier. We also wish to thank Mr. Robert O'Daniel, Ms. Joan Kaufmann, and Ms. Linda Reimers for assisting us with

the editorial work. M. J. Plavec D. M. Popper R. K. Ulrich  
**ACKNOWLEDGEMENTS** The International Astronomical Union and the University of Toronto contributed substantial funds enabling a number of participants to receive travel grants. The Symposium was sponsored by the following Commissions of the International Astronomical Union: 29 (Stellar Spectra), 30 (Radial Velocities), 35 (Stellar Structure), 42 (Close Binary Stars), and 44 (Astronomy from Space). Our special thanks go to the members of the Scientific Organizing Committee. The Symposium was attended by 170 participants from 26 countries.

*Active Close Binaries* CUP Archive

These proceedings celebrate the achievements of the great astronomer Zdenek Kopal, and reflect the state of the art of the dynamically evolving field of binary research, which owes so much to Kopal's pioneering work.

**Zdenek Kopal's Binary Star Legacy** Springer Science & Business Media

This book contains the proceedings of IAU Symposium No. 151 'Evolutionary Processes in Interacting Binary Stars,' which was held from 5 to 9 August 1991 in Córdoba, Argentina. The primary aim of this conference was to review and evaluate our current understanding of the evolutionary processes in wide variety of interacting binary stars from their births to their deaths. Subjects included the formation of binaries, mass flow and transfer, accretion processes, and binaries with collapsed components, such as novae, X-ray binaries and binary pulsars. As the field covered is both broad and diverse, there were in all thirty-seven invited talks; sixty-two contributed papers were also presented. In addition, these proceedings contain comments from a panel discussion of the major unsolved problems of interacting binary stars.

**Evolutionary Processes in Interacting Binary Stars** Springer Science & Business Media

Analysis was performed on observations of the binary star systems NP Andromedae and V1120 Ophiuchi. The raw CCD images were calibrated and aperture photometry was performed to obtain the light curves for both systems. The period was calculated for NP And using the Period04 program, and the period was calculated for V1120 Oph by using an O - C period study. The spectral type and temperature were determined by color indices for both star systems. The Wilson-Devinney method was used to

obtain geometric and astrophysical parameters for NP And, and a 3-D model was constructed of the NP And star system using Binary Maker. The light curves confirmed that both star systems were in fact W UMa star systems. NP And was determined to be an A-type W UMa system with a cool spot on the primary star. There was not enough data to do a complete photometric analysis of V1120 Oph.

**Eclipsing Binary Stars** Springer Science & Business Media  
 Binary systems of stars are as common as single stars. They are of fundamental importance because they allow stellar masses, radii and luminosities to be measured directly, and explain a host of diverse and energetic phenomena including X-ray binaries, cataclysmic variables, novae, symbiotic stars, and some types of supernovae. This 2001 book was the first to provide a pedagogical and comprehensive introduction to binary stars. It combines theory and observations at all wavelengths to develop a unified understanding of binaries of all categories. It comprehensively reviews methods for calculating orbits, the Roche model, ideas about mass exchange and loss, methods for analysing light curves, the masses and dimensions of different binary systems, and imaging the surfaces of stars and accretion structures. This book provides a thorough introduction to the subject for advanced undergraduate and graduate students. Researchers will also find this to be an authoritative reference.

*Language of the Stars* Cambridge University Press

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**Critical Observations Versus Physical Models for Close Binary Systems** Springer

Proceedings of the IAU Symposium No. 88 held in Toronto, Canada, August 7-10, 1979979

*The Study of Variable Stars Using Small Telescopes* Springer Science & Business Media

The techniques of visual, photographic and photoelectric measurement of variable stars are accompanied by specific examples of the type of scientific results that can be and have been obtained.

*Light Curve Modeling of Eclipsing Binary Stars* Springer

It is now clear that a binary evolutionary pathway is responsible for a significant fraction of all planetary nebulae, with some authors even going so far as to claim that binarity may be a near requirement for the formation of an observable nebula. This has led to the requirement that textbooks most likely need to be rewritten. Building upon the review of Jones and Boffin in *Nature Astronomy* (2017), this Springer Brief takes a first step in this direction. It offers the first expanded presentation of all the theoretical and observational support for the importance of binarity in the formation of planetary nebulae, initially focusing on common envelope evolution but also covering wider binaries. This book emphasises the wider impact of the field, highlighting the critical role binary central stars of planetary nebulae have in understanding a plethora of astrophysical phenomena, including type Ia supernovae, chemically peculiar stars and circumbinary exoplanets.

*Binary Stars* Springer Nature

Introduction to Close Binary Systems provides a comprehensive survey and guide to the fast-moving field of multiple, specifically binary, stars, with an up to date account of research around

'close', i.e. interacting pairs. Such interactions allow direct quantification of stellar properties, opening up factual insights into basic building blocks of the Universe. The book provides a much needed update for the seminal *Close Binary Systems* of Zdeněk Kopal. Following a comparable plan, it presents relevant subject matter with an emphasis on building a framework of understanding to serve as a supporting resource for students and researchers. The text starts from a general historical background and progresses into the main theoretical ideas supporting our *prima facie* interpretation of observations. The central chapters explore further into these observational methods, arranged according to the classic subdivisions of astrometry, spectroscopy and photometry. Optimal inversion of observational data into model parametrization is a theme through these chapters. Significant here is the problem of how non-uniqueness in modelling affects interpretation. The underlying issues of stellar evolution bearing on observational evidence become paramount in the last four chapters. The book proceeds step-by-step from directly understandable examples of unevolved pairs to the challenging cases where stars are found in more and more extreme conditions, leading up to the mergers of massive black hole pairs seen in the new field of gravitational wave astronomy. This is a valuable reference for postgraduate and advanced undergraduate students working in mainstream areas of stellar astrophysics, with applications also to exoplanet research which shares some methodological features. Course designers for stellar astrophysics will find a useful selection of topics within this book. Key features: • Provides a well-explained and backgrounded, up-to-date account of close binary systems, in a fast-moving field of research that is growing in scientific importance • Surveys a wide range of case-studies within the context of binary and multiple star systems • Fills an acknowledged gap in current literature

Cover Image: A public memorial to Zdenek Kopal in his home town (birthplace) of Litomysl in Czechia.

#### Observing Variable Stars Springer

Observing variable stars is one of the major contributions amateur astronomers make to science. There are 36,000 variable stars listed in the General Catalogue of Variable Stars, so it is clearly impossible for the limited number of professional observatories to target even the majority of them. That's where amateur astronomers come in - thousands of them turning their

telescopes to the sky every night. Variable star observing is the most popular of "real science" activities for amateurs, and Gerry Good's book provides everything needed. The first part of the book provides a highly detailed account of the various classes of variable star, with examples, illustrations and physical descriptions. The second section covers practical aspects of observing, everything from preparation and planning, through observing techniques, to data management and reduction. *ICCD Speckle Observations of Binary Stars XXII* Springer Science & Business Media

Focussing on the formulation of mathematical models for the light curves of eclipsing binary stars, and on the algorithms for generating such models, this book provides astronomers, both amateur and professional, with a guide for - specifying an astrophysical model for a set of observations - selecting an algorithm to determine the parameters of the model - estimating the errors of the parameters. It is written for readers with knowledge of basic calculus and linear algebra; appendices cover mathematical details on such matters as optimisation, co-ordinate systems, and specific models. While emphasising the physical and mathematical framework, the discussion remains close to the problems of actual implementation. The book concludes with chapters on specific models and approaches and the authors' views on the structure of future light-curve programs. Eclipsing Binary Stars Springer Science & Business Media

Peter P. Eggleton and James E. Pringle Institute of Astronomy Madingley Road Cambridge England

The 1970's can be described, in retrospect, as the "Decade of the Close Binary". Exciting observations with new technology, combined with classical work, both observational and theoretical, convinced the astronomical world that binary interaction of various kinds is not only interesting but common. Indeed, by 1975 almost anything unusual had a good chance of being interpreted as due to binary interaction. But astronomers are seldom overwhelmed by speculation, even their own, and solid observational work has confirmed or refuted such speculation, without regard to its plausibility. For instance, binarity has been found where it was perhaps least expected, in Barium stars, and refuted where it could most reasonably be expected, in Wolf-Rayets. Unfortunately, many other classes of potential binaries remain without the clearest evidence of binarity, for instance Be stars,

symbiotics and blue stragglers. This Advanced Study Institute was held to commemorate John Whelan (1945-1981), whose scientific career, sadly cut short in its prime, did much to further the careful study, theoretical and observational, of close binaries, as well as to encourage the spirit of international friendship and collaboration. His own interests covered a greater field, but "Interacting Binaries" seemed a reasonable restriction. We publish here 15 review talks, which still do not cover the whole topic, although they range widely.

#### *Close Binary Stars: Observations and Interpretation* Elsevier

More than half of all stars in the universe formed and evolved as binary systems and their study is essential for understanding stellar and galactic evolution. The six lectures in this book give both a readable introduction and an up-to-date review of nearly all aspects of research into binary stars, including the range from common binaries to more exotic systems composed of white dwarfs, neutron stars and black holes.

#### Close Binary Stars: Observations and Interpretation Springer Science & Business Media

Eclipsing Variables - What They can Tell Us and What We can do with Them The aim of the present book will be to provide an introduction to the interpretation of the observed light changes of eclipsing binary stars and their analysis for the elements of the respective systems. Whenever we study the properties of any celestial body - be it a planet or a star - all information we wish to gain can reach us through two different channels: their gravitational attraction, and their light. Gravitational interaction between our Earth and its celestial neighbours is, however, measurable only at distances of the order of the dimensions of our solar system; and the only means of communication with the realm of the stars are their nimble-footed photons reaching us - with appropriate time-lag - across the intervening gaps of space. As long as a star is single and emits constant light, it does not constitute a very revealing source of information. A spectrometry of its light can disclose, to be sure, the temperature (colour, or ionization) of the star's semi-transparent outer layers, their chemical composition, and prevalent pressure (through Stark effect) or magnetic field (Zeeman effect), it can disclose even some information about its absolute luminosity or rate of spin. It cannot, however, tell us anything about what we should like to know most - namely, the mass or size (i.e., density) of the

respective configuration; its absolute dimensions, or its internal structure.

[Interacting Binary Stars](#) Springer Science & Business Media

IAU S240 focuses on recent advances across the broad field of binary star research.

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