DYNAMICS OF CLOSE BINARY SYSTEMS

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2 hours weekly.

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2 hous weekly.

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PREFACE

The main aim of this thesis has been to suggest a model of non-conservative evolutionary case of close binary systems.

In Chapter I the subject is introduced in a general way. It is intended in this chapter to propose the definition, classification and physical properties of close binary stars with reference to the Roche model of such stars. The origin and the theory of evolution are also introduced.

Chapter II is concerned with the geometry of the Roche equipotential surfaces which clarify the limits of stability of the Algol type systems through the evolutionary stages.

An analytical discussion of the mass exchange problem of Algol-type stars is given in Chapter III, with the assumption that mass and angular momentum will remain preserved.

In Chapter IV a numerical solution for the non-conservative model is given. Mass loss and mass gain relations are derived. The rate of mass transfer and/or loss as well as the rate of orbital angular momentum of the binary system have been found during the evolutionary stages. The results obtained for the non-conservative model have been represented graphically using the data of the semi-detached Algol-type binary system R.Y.Persei.

CHAPTER I

CHAPTER I

BASIC CONCEPTS OF CLOSE BINARY STARS

1. DEFINITIONS AND PHYSICAL CONCEPTS:-

We are going to start by giving some definitions and physical concepts which will help us to understand the structure and the processes of evolution of close Binary Systems.

1.1 Double Stars:

They are stars which appear, to the naked eye, as a single luminous point, but when viewed through a telescope they are found to be composed of two distinct stars. The two stars may be connected gravitationally (e.g. Binary Systems), or they may be at different distances and are far apart but nearly on the same line of sight. This latter type, where there is no physical relation between the two stars, the system is called an "Optical double".

1.2 Binary Systems:

A binary system is defined as one which consists of two stars that describe closed orbits around their common centre of gravity, under the influence of their mutual gravitational attraction.

A binary system is said to be "closed" if either component expands during its evolution to such a degree that it fills up its "Roche lobe" (See, §3 below) and mass exchange, between the two stars, takes place.

1.3 The Hertzsprung - Russell Diagram:

The H - R diagram is recognized as a powerful tool for the study of stellar evolution. It represents the relationship between spectral types, for the stars of known distances, and luminosity. This diagram is also known as a colour - magnitude diagram. In the H - R diagram, stars fall in four main regions: a band, which contains the majority of the stars, called the main sequence and three other groups called giants, supergiants and white dwarfs. The main features of the Hertzsprung - Russell diagram are represented in Fig (1-1).

2. CLASSIFICATION OF BINARY SYSTEMS:

According to the methods of observation, such as: ostrometric (measures determining positions), spectroscopy (measures of radial velocity), and photometry (measures of light intensity), binary systems can be divided into the following groups:

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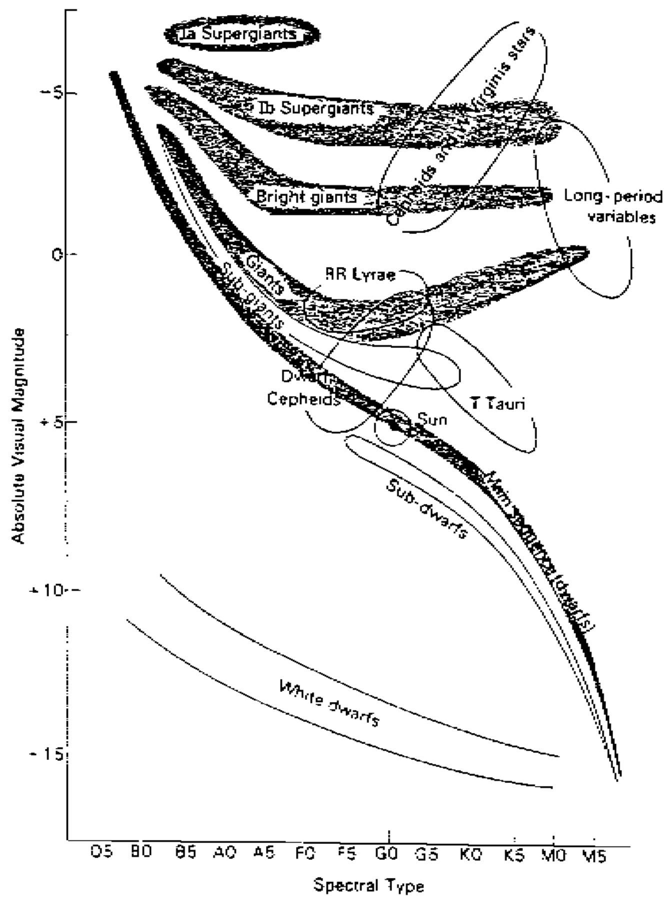

Fig.1.1. The Hertzsprung-Russell Diagram

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2.1. Astrometric or Visual Binary Systems: These are binary systems whose components are seen in the telescope to be clearly separated. In most of these cases the component separations are relatively large, and the orbital motions are slow.

2.2. Spectroscopic Binaries: The two components of these systems are so close together that they can not be resolved optically by a telescope. They are only detected by the variation of their radial velocities.

2.3. Photometric Binaries or Eclipsing Variables: These are oriented so that the two components eclipse each other as seen from the Earth.

All eclipsing binaries are at least potentially spectroscopic binaries. Some visual binaries can also be profitably observed spectroscopically. Only few binaries can be observed in all three ways.

Many schemes for the classification of photometric binaries have been proposed by different astronomers depending on different basis such as Krat in 1944, Struve in 1951 , Plaut in 1953 and Sahade (1960).

A well recognized classification based on a completely different principle, is that given by Kopal (1955).

3. The Roche Lobe:

Kopal's classification (1955) of binary stars is based on the consideration of the gravitational potential in the space surrounding a binary system. The presence of a companion star in the close neighbourhood of another star necessitates an upper limit for the size that this star can reach. We are going to show in chapter III below that this upper size-limit usually corresponds to one of the zero velocity surfaces of the restricted three body problem. The relative dimensions of this surface are completely specified by the ratio of masses of the two stars. This surface is usually referred to as the Roche Limit, while some authors prefer other phrases such as "Lagrangian Surface" or "Limit of Stability". In the present work, this surface will be referred to as "The critical surface", and the volumes enclosed by the two components will be called the "Roche Lobes" (see Fig.1.2).

According to Kopal's classification all binary systems are divided into three groups (see Fig. 1.3):

(i) Detached Systems:

Systems in which neither component fills the Roche lobe.

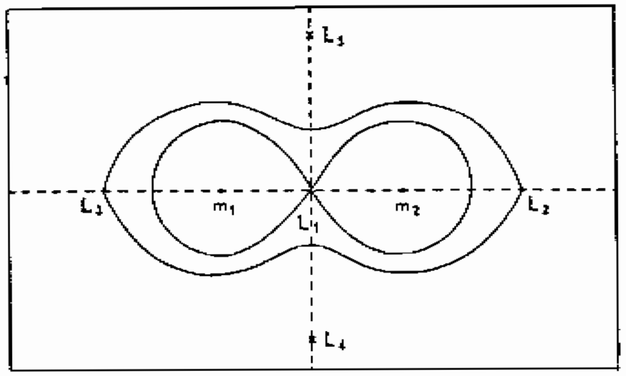

Fig. 1.2. The inner and outer Roche limits in close binary systems consisting of two components of equal mass.

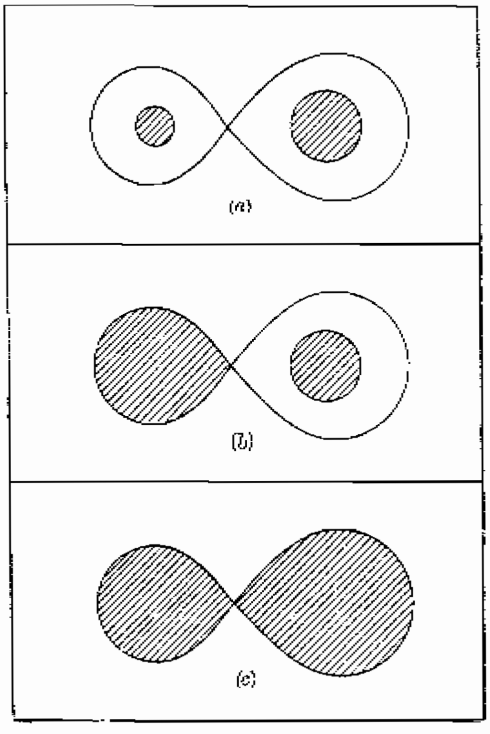

Fig.1.3. A Schematic view of the three principal types of close binary systems: (a) detached systems; (b) semi-detached systems; (c) contact binaries.