A GENERAL CATALOGUE OF EPHEMERIDES AND APPARENT ORBITS FOR VISUAL BINARIES

YAN LIN-SHAN
Shanghai Observatory, Academia Sinica, Shanghai, China

Summary. Informations on 736 pairs of visual binaries are given in the form of the Tables. The General Catalogue gives ephemerides \( t, \theta^o, \rho^o \) in 20 years (1984–2003) for each pair with the figures of its apparent elliptical orbit where the positions of secondary component relative to the primary one at different epochs are indicated. The General Catalogue contains four parts: Part one – Source and Grading of Orbit; Part two – Ephemerides and Atlas of Apparent Orbits; Part three – Classifications of Visual Binary Stars; Part four – Indexes of Visual Binary Stars. The principle of calculation and the statistical data are presented in this paper. There are seven statistical tables, giving the elements distribution of true and apparent orbits, grading distribution of orbits, number distribution with different physical property of component of binary star. The number of binary stars in anyone constellation, the number of binary stars brighter than \( 6^m 5 \). The number of binary stars nearer than 25 parsec.

1. Introduction

The ephemerides of binary stars are the important informations for astronomical observation and research. After 1950, many ephemerides had been compiled by Müller (1954), Müller and Mayer (1964, 1969), Müller and Couteau (1979), and Wepner (1967), and so on. In recent years, orbital elements of several hundred pairs have been re-computed and many new binaries were discovered. It becomes necessary to set up perfect ephemerides. Our General Catalogue is based on the Finsen and Worley (1970) third catalogue of orbits of visual binary stars and on our many new data and new results collected. Informations on 736 pairs of visual binaries are given in the form of the Tables. The General Catalogue gives ephemerides \( t, \theta^o, \rho^o \) in 20 years (1984–2003) for each pair with the figures of its apparent elliptical orbit where the positions of the secondary component relative to the primary one at different epoch are indicated. Apparent elliptical elements are given below each atlas. At this point, our General Catalogue is only one. It is different from all other ephemerides.

2. Principle of Establishing Apparent Orbit

In the case of the orbital elements \( a, e, i, \Omega, \omega, p, T \) of visual binaries have been known, we could calculate the orbital motion on tangential plane on the celestial sphere ephemerides.

First at all, we set up two coordinate systems to find the elements of apparent ellipse. Let \( a \) and \( e \) represent the size and form of the ellipse, \( \theta \)-position angle of major axis and \( (x'_0, y'_0) \)-coordinates of apparent ellipse center.

Take rectangular coordinate system \( S – xyz \). The primary \( S \) is the origin of coordiantes, \( xy \)-plane with reference to true orbit plane. The \( a \)-axis towards the
periastron, and y-, z-axes both follow the right-hand rule. Since the primary S is at a focus of the true ellipse orbit, the equation takes the form

$$\frac{x^2}{a^2} + \frac{y^2}{a^2(1 - e^2)} = 1 ,$$

(1)

As for S - x'y'z' system, the origin is the primary star S, apparent orbital plane is x'y'-plane, but x'-axis towards the north, y' towards the east, z' is perpendicular to x'y'-plane and follows the right-hand rule.

2.1. COEFFICIENTS OF THE EQUATION OF THE APPARENT ELLIPSE

In the S - x'y'z' system, the apparent orbit equation takes form

$$Ax'^2 + 2Bx'y' + Cy'^2 + 2Dx' + 2Ey' + F = 0 .$$

(2)

These coefficients will be determined. Relate the two coordinate systems by Eulerian angles $i\omega\Omega$, we have

$$\begin{pmatrix} x' \\ y' \\ z' \end{pmatrix} = R_z(-\Omega)R_x(-i)R_z(-\omega) \begin{pmatrix} x \\ y \\ z \end{pmatrix} ,$$

(3)

$R_z$, $R_x$ show the orthogonal rotation matrix, defined by

$$R_x(-i) = \begin{pmatrix} 1 & 0 & 0 \\ 0 & \cos(-i) & \sin(-i) \\ 0 & \sin(-i) & \cos(-i) \end{pmatrix} , \quad R_z(-\omega) = \begin{pmatrix} \cos(-\omega) & \sin(-\omega) & 0 \\ -\sin(-\omega) & \cos(-\omega) & 0 \\ 0 & 0 & 1 \end{pmatrix} .$$

The direction of $\omega$ is positive when we rotate any point counter-clockwise in the true ellipse, its coordinate $z = 0$. From Equation (3), $x'$, $y'$ are linear function of $x$, $y$. Substitute these $x$, $y$-values into Equation (1), we may obtain these coefficients $A$, $B$, $C$, $D$, $E$, $F$, which are the functions of the elements of $a$, $e$, $i$, $\omega$, $\Omega$, respectively.

2.2. THE POSITION OF THE APPARENT ELLIPSE

The coordinates of true ellipse center in the S - xyz system are $x_0 = -ae$, $y_0 = 0$. Substitute these coordinate values into Equation (3), we find $(x'_0, y'_0)$, but the major axis position angle $\theta$ of apparent ellipse is found from the equation

$$\cot 2\theta = \frac{A - C}{2B} .$$

2.3. THE SIZE AND FORM OF THE APPARENT ELLIPSE

Take the coordinate system $O - XYZ$: $O$ is the origin and denotes the center of apparent