15.1: Introduction

Chapter 14 dealt with the subject of *general perturbations*. That is, if the perturbation R can be expressed as an explicit algebraic function, the rates of change of the orbital elements with time can be calculated by explicit algebraic expressions known as *Lagrange's Planetary Equations*. By way of example we derived Lagrange's Equations for the case of a satellite in orbit around an oblate planet, in which the departure of the gravitational potential from that of a spherically symmetric planet could be expressed in simple algebraic form.

Lagrange's Equations are important and interesting from a theoretical point of view. However, in the practical matter of calculating the perturbations of the orbit of an asteroid or a comet resulting from the gravitational field of the other planets in the solar system, that is not how it is done. The perturbing forces are functions of time which must be computed numerically rather than from a simple formula. Such perturbations are generally referred to as *special perturbations*. While long-established computer programs, such as RADAU15, may be available to carry out the necessary rather long computations without the user having to understand the details, it is the intention in this chapter to indicate in principle how such a program may be developed from scratch.

Jupiter is by far the greatest perturber, but for high-precision work it may be necessary to include perturbations from the other major planets, Mercury to Neptune. Pluto may also be considered. However, it is now known that Pluto is a good deal less massive than it was once estimated to be, so it is a nice question as to whether or not to include Pluto. Besides, Pluto is probably not the most massive of the transneptunian objects - Eris is believed to be a little larger and hence possibly more massive. The main belt object Ceres may be more important than either of these. The total mass of the remaining asteroids is usually considered negligible in this context.

It will be evident that any computer program intended to compute special perturbations will have to include, as subroutines, programs for calculating, day-by-day, the positions and distances of each of the perturbing planets to be included in the computation. Computer programs are available to provide these. In what follows, it will be assumed that the reader has access to such a program (I do!) or is otherwise able to compute the planetary positions, and we move on from there to see how we calculate the planetary perturbations.