Abstract. In the text-books of astronomy, sections generally related to the Moon deal with the orbital elements of the Earth–Moon system such as $a$, $e$, $i$, $\Omega$, $\varpi$ and the time of perigee passage $\tau$. While the MEAN of the first of the three elements do not vary, mean longitude of the ascending node–mean longitude of the lunar perigee and the time of perigee passage undergoes secular as well as periodic changes due predominantly to the action of the Sun’s gravitational attraction. While to a certain degree, explanations related to the calculation of the lunar orbit parameters are given, not a single graphical representation of these short- or long-periodic changes are presented. We allow the number of data related to these periodic changes must cover a large span of time; and if regression of the line of nodes or advances of the line of apses are to be graphically seen, data covering 18.61 and 8.85 yr, respectively, are needed. In this work we particularly aim at the graphical representation of the periodic changes of the line of nodes.

1. Introduction

The Moon moves in an approximately elliptic orbit inclined by about five degrees to the plane of ecliptic. The mean values of the semimajor axis $a$, the eccentricity $e$ and the inclination $i$ are given as

$$a = 384399.7 \text{ km} \quad e = 0.05490 \quad \text{and} \quad i = 5^\circ 08' .$$

Because of the perturbations produced by the solar system, in particular the eccentricity of the orbit varies from 0.044 to 0.067 while the inclination oscillates between $4^\circ 59'$ and $5^\circ 16'$.

Various periods of revolution of the Moon in its orbit may be defined as synodic (the time between successive similar configurations with the Sun – i.e., new moon to new moon, 29$^d$530589). The tropical (the time between the successive passages through the Equinox, 27$^d$321582). Sidereal (the time required by the Moon to cover 360$^\circ$, 27$^d$321662). Anomalistic (the time between successive passages of the Moon through perigee, 27$^d$554550) and another lunar month can be defined by the time it takes the Moon to return to its ascending node. The so-called draconic is the nodal month and its length is 27$^d$212221 days. Although in any revolution of the Moon in its orbit, these months may differ by a few hours from the given
values above, the mean values remain steady over many centuries (cf., e.g., Roy, 1982).

The other three elements of the Moon's orbit, the longitude of the ascending node $\Omega$ - the longitude of the perigee $\omega = \Omega + \omega$ and the time of perigee passage suffer secular as well as periodic changes due predominantly to the action of the Sun's gravitational attraction. The line of nodes recedes in the plane of ecliptic, accomplishing one revolution in about 18.6 yr while the line of apses advances, completing one revolution in about 8.85 yr.

In the textbooks of astronomy (Essentials of Astronomy, 1977 Textbook on Spherical Astronomy, 1984; Orbital Motion, 1982; Dynamical Astronomy, 1984; Spherical Astronomy, 1985; Introductory Astronomy and Astrophysics, 1987) various kind of data summarized above and related to the Earth–Moon system, are given; whereas within the same literature, graphical representation of any periodic event is not given. On the other hand the data related to any long periodic event must be gathered or obtained through laborious calculations for a long period of time.

In the past high speed computational facilities and before 1985 Graphical Representation Software Packages and related peripheral hard copy devices (Plotters) were not widely used. Hence up to until recent years solution of some problems in the Earth–Moon system remained merely as numbers. Today with the availability of personal computers equipped with high-speed and suitable memory configurations and with the advent of professional software packages, periodic events such as mentioned above could be resolved and the numerical results could be corroborated with the graphical presentations. We are convinced that widespread usage of personal computers and professional graph packages will modify the appearance of general and computational astronomy.

2. Solutions of Equations

The construction of a complete lunar ephemeris which not only includes the effects of the Sun, Earth, planets and the figures of Earth and Moon, which can also be compared with observations is one of the most difficult problems in astronomy. The basic lunar theory was developed by E. W. Brown in the beginning of the 20th century. His Tables of the Motion of the Moon are the most exhaustive and elaborate treatment of the problem where nearly 1500 separate terms were considered. The theory consists of forming expansions for the ecliptic longitude, latitude and horizontal parallax of the Moon. Each of the series expansion consists of hundreds of terms. The first two terms are of the form

$$\lambda = L' + \sum a_{ijkl} \sin(iM' + jM + kF + lD),$$

$$\beta = \sum b_{ijkl} \sin(iM' + jM + kF + lD),$$

$$\sin P = \sin P_0 + \sum c_{ijkl} \sin(iM' + jM + kF + lD),$$