THE UNIT OF TIME-INTERVAL

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RÉSUMÉ. — L'auteur considère que l'adoption d'une définition physique d'une unité d'intervalle de temps en remplacement de la seconde de temps des éphémérides n'aurait aucune répercussion sérieuse en astronomie dynamique, théorique ou appliquée, ni sur le système des constantes astronomiques.

ABSTRACT. — It is suggested that the adoption of a physical definition of the unit of time-interval, to replace the ephemeris second, would have no serious effect on the theory and practice of dynamical astronomy, or on the system of astronomical constants.

ZUSAMMENFASSUNG. — Es wird darauf hingewiesen, dass die Annahme einer physikalischen Definition der Einheit des Zeitintervalles anstelle der Ephemeridenzeit-Sekunde keine bedenkliche Auswirkung auf die Theorie und Praxis der Himmelsmechanik oder auf das System der astronomischen Konstanten haben würde.

Резюме. — Автор указывает, что принятие физического определения единицы промежутка времени, вместо секунды эфемеридного времени, не будет иметь серьёзного влияния на систему астрономических постоянных ни, вообще, на динамическую, теоретическую или прикладную астрономию.

At the second meeting, in April 1961, of the Comité consultatif pour la définition de la seconde of the Comité International des Poids et Mesures, a resolution was adopted encouraging laboratories to proceed with the establishment of atomic frequency standards of high precision with a view to the eventual submission to the twelfth Conférence Générale des Poids et Mesures (to be held in 1966) of a new definition of the unit of time-interval. The present unit, the ephemeris second, was adopted by the Comité International in 1956 and ratified by the eleventh Conférence Générale in 1960. It seems desirable to consider the effect on astronomy, and particularly on astronomical constants, of the adoption of a physical definition of this unit.

In the dynamical astronomy of the solar system, the mass of the Sun, the astronomical unit and the ephemeris second form a sufficient system of units, independent of the physical units of mass, length and time. However, observations are made relative to *transmitted* universal time, which is arithmetically linked with a physical standard; corrections, based on observation, are (when necessary) applied to provide U. T. 0 or U. T. 1, for studies concerned with the rotation of the Earth, and E. T., for comparison with theory. The motions of satellites of the Earth are naturally observed in terms of the physical units of length and time-interval. The question is whether any contact arises between the two systems such that confusion may be caused by any uncertainty in the ratio R between a physical unit of time-interval and the ephemeris second; this ratio is not necessarily constant with time, but its drift is small compared with the present uncertainty of about 2 or 3 parts in 10^9 in its observed value.

An exact value has been adopted for the Gaussian gravitational constant, k, which serves to define the astronomical unit. The fundamental relationship, corresponding to Kepler's third law, is

$$n^2 a^3 = \mathrm{GM},$$

where n and a are the mean motion and semi-major axis of the elliptic orbit of a particle of negligible mass about a primary of mass M, and G is the constant of gravitation in appropriate units. For the Sun as primary, and with the mass of the Sun as unity,

$$n^2 a^3 = k^2 = (0 \cdot 01720\ 20989\ 50000)^2,$$

where n is measured in radians per day of 86 400 ephemeris seconds, and a is measured in astronomical units.

If a unit of time-interval (the physical second) is adopted such that its duration is R ephemeris seconds, and if the astronomical unit contains A cm, then, for a primary of mass M (in terms of the Sun's mass),

$$n^2 a^3 = \mathrm{MR}^2 \mathrm{A}^3 \times \mathrm{C}k^2,$$

where n is measured in seconds of arc per physical second and a is in centimetres; C, a numerical constant,is $(206\ 264 \cdot 80625 / 86\ 400)^2$. Precise observations of n and a will thus give a precise value of $\mathrm{MR}^2\mathrm{A}^3$; but, even if A is known with high precision, the uncertainty in M is likely to be very much larger than that of R.

For motion about the Earth, the value used for $\mathrm{MR}^2\mathrm{A}^3$ must be the same for the Moon as for an artificial satellite. The mean motion of the Moon is theoretically referred to ephemeris time so that the quantity apparently deduced from observation is MA^3; but the ratio R is in practice determined by comparing the motion of the Moon, as observed in the reference frame of physical time, with the theory, so that the comparison is in fact direct. A conventional, exact, value for MR^2A^3 can be adopted for the Earth without conflict with the adopted value for k.

It would thus appear that the two systems of units, particularly as regards the unit of time-interval, are almost independent. For a body in orbit round the Sun, making a very close approach to the Earth, the time system used for observation would of necessity have to be based on the physical unit; the two units of time-interval would not enter. It may be concluded that the adoption of a new definition of time-interval, based on a physical standard of frequency, would not in this context have any significant effect on dynamical astronomy.