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LUNAR THEORY

Hori (**1**) developed Brouwer's project for the lunar theory on the basis of von Zeipel's method. As a first attempt he neglected the orbital inclination and obtained the solution in powers of m, but in a closed form with respect to the eccentricity. He computed as far as the order m^4 for the periodic terms and as far as m^5 for the secular terms. He has just completed the computation in closed forms with respect to both the eccentricity, the inclination and the solar eccentricity as far as the order m^4.

Stumpff's lunar theory (**2**) is based on the use of his so-called invariants and the main equation in his theory of the two-body problem. He considers the differential equations for Hill's variational orbit in his lunar theory in two dimensions, and obtains a relation of the form $f(\dddot{r}, \ddot{r}, \dot{r}, r; C) = 0$. The equation can be integrated numerically by iteration if the Moon's orbit is considered to be a disturbed Keplerian ellipse with any value of the eccentricity, for a certain fairly extended time interval in the vicinity of the initial epoch. The iteration process is limited to the solution of the transcendental main equation. In the second paper Stumpff expanded the co-ordinates in powers of Hill's m in a manner different from Hill's.

Schubart (**3**) published his work on the extension to three dimensions of the family of periodic orbits of Hill's lunar problem of two dimensions. For representing the third co-ordinate a new variable is introduced. The series obtained are proved to be convergent by the procedure of Siegel.

In 1961, at Berkeley, Eckert reported that Brown's harmonic series for the co-ordinates of the Moon had been substituted into the differential equations and the residuals obtained with precision, and outlined a method for the solution of the variation equations which would overcome the difficulties arising from the small divisors. Eckert wrote me that the method had been developed since and the programmes necessary to generate and solve the variation equations on the 7094 computer had been completed and applied to about 3500 residuals. The results appear to be completely satisfactory according to Eckert. The corrections obtained from the solution are now being applied to the initial series and the corrected series substituted in the differential equations. Eckert plans to repeat the entire process at least once with appropriate variations to estimate the stability of the results. He says that his machine programmes permit a complete solution with little effort compared to that already expanded on the problem.

Van der Waerden (**4**) considered the secular terms and fluctuations in the motions of the Sun and the Moon from two causes. The one is due to the tidal friction and it causes the secular retardation of the motion of the Moon. The other is the irregular rotation of the surface of the Earth due to random currents in the interior of the Earth.

Kovalevsky (**5**) is continuing his work on the theory of motion of the eighth satellite of Jupiter, according to the principle of successive approximations, but is obliged to wait until a more powerful computer can be utilized. He is also working on the long-period terms in the motion of the eighth to the twelfth satellites of Jupiter. Mello is engaged in the theoretical study on the interaction of three satellites of Jupiter.

Kondurar (6) has considered the motion of a satellite in Hill's problem of three bodies around a planet having a spheroidal shape.

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ARTIFICIAL SATELLITES

Apart from the theories of the motion of an artificial satellite by King-Hele, Brouwer, Garfinkel, Kozai and others, Vinti (1) has succeeded in integrating the equations of motion of

$$U = -\frac{\mu}{r}\left[1 - \sum_{n=1}^{\infty} J_n \left(\frac{R}{r}\right)^n P_n(\sin\beta)\right]$$

by means of Hamilton-Jacobi's method in the separation of variables. According to this idea Izsak (2) has considered as his intermediary orbit for the motion of an artificial satellite the motion in the gravitational potential of the Earth by taking into account the coefficients of the zonal harmonics as far as the second order with respect to J_2. The ingenious assumption which Vinti made leads to the separation of variables if $J_{2n} = (-1)^{n+1} J_2^n$, $J_{2n+1} = (-1)^n J_1 J_2^n$. Observations show that the error $J_4 + J_2^2 \sim -10^{-6}$. Since J_1 is practically zero, the potential

$$U = -\frac{\mu}{r}\left[1 + \sum_{n=1}^{\infty} (-J_2)^n \left(\frac{R}{r}\right)^{2n} P_{2n}(\sin\beta)\right]$$

is a good approximation. If oblate-spheroidal co-ordinates are used, then the Hamilton-Jacobi equation of the problem is of Stäckel's type. The solution can be expressed in elliptic integrals. By referring to the theory of elliptic functions with a linear fractional transformation in the complex domain Izsak expressed the solution in Fourier series and the integration constants as funtions of the Keplerian elements.

Vinti (3) tried to simplify Izsak's process of solution and expressed it in terms of the complete elliptic integrals by avoiding the use of complicated elliptic functions, that is, by obtaining the solution as the sum of integrals containing quartics which are evaluated by convergent Fourier series, and then transformed by uniformizing with the eccentric anomaly. Vinti (4) deduced the mean motion in such a conditionally periodic separable system. Then he (5) removed the restriction on the orbital inclination $I_c < I < 180° - I_c$, where I_c might be as large as 1° 54′ for an orbit sufficiently close to the Earth. Many of the formulae for the periodic terms are simplified when the orbit is equatorial or almost equatorial.

Bonavito (6) announces that Vinti's solution goes very fast on the IBM 7090. Shapiro (7) discussed the prediction of satellite orbits.

Callander (8) shows the motion of an artificial close satellite to be quasi-periodic by obtaining the bounds of the variation of the radial distance and the variation of the inclination. Poritsky (9)