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Solar Radiation Pressure and the Motion of Earth Satellites

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The main works devoted to the study of the effects of solar radiation pressure on the motion of artificial earth satellites are reviewed. The resonance case, when the motion of the satellite undergoes long-period variations with large amplitudes, is considered in detail. The graphs given in the paper permit easy determination of the presence of resonance for a wide range of satellite orbits, provided that the orbital elements are known. The graphs were constructed on the assumption that the effect of the earth's shadow can be neglected.

Introduction

ONLY a few years ago, when the intense work of creating a theory of artificial satellite motion was begun, it was assumed that the effect of light pressure or of solar radiation is negligibly small as compared to the influence of the earth's oblateness and the effects of lunar-solar gravitation. However, the investigations of the motion of the satellite "Vanguard 1" (1958 β_2) showed that, even if the total lunar-solar gravitation effect is taken into account, no full agreement between theory and observation is obtained. It was precisely the need of explaining this discrepancy which prompted the study of the effect of light pressure, thus initiating the theoretical and experimental work in this field. Various authors (Musen,[12] Parkinson, Jones, and Shapiro[15]) analyzed the orbital perturbations of the satellite 1958 β_2 due to radiation pressure, and the secular perturbations were determined in the first approximation. It was assumed that the orbit is continuoulsy illuminated and that the reflection from the satellite surface is specular. The effect of re-radiation from the earth and the Poynting-Robertson accelerating effect were disregarded. The magnitude of the acceleration due to radiation pressure, estimated for the satellite 1958 β_2, was found to be approximately 10^{-5} cm/sec^2.

By processing the observations of the satellite 1958 β_2 over a period of approximately two years from launching, a perigee-height perturbation with an amplitude of 1–2 km and a period of about 850 days was determined. In conjunction with the lunar-solar effect, which yields roughly the same amplitude but only half the period, allowance for this perturbation results in good agreement with theory. Yet, in this case, the observed effect of radiation pressure was so small that even toward the end of the two-year period the magnitude of the effect was still determined with an accuracy of not more than 30%. The accuracy of determining the magnitude of the radiation pressure from observations of the satellite "Echo 1" (1960 ι_1) was much greater, even during the first month of observations, since the corresponding variations in the orbit of "Echo 1" are much greater than in the orbit of "Vanguard 1." These variations in the orbit of

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