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Use of long-term models for analysis of comet Encke's motion

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Abstract

This paper is focused on the problem of the reactive non-gravitational effects change in the cometary motion caused by the comet's activity fading. The modern researches have been reviewed. The necessity of a new model compatible with Marsden's model of non-gravitational forces is shown. Modifications of Marsden's model for the cases in which the main factors of the parameters change are the deposition of the significant non-volatile mass and the growth of the superficial crust are developed. They contain besides the usual Marsden's parameters two and three additional values correspondingly. The developed equations have been used to explain the known change of Marsden's non-gravitational parameters for the comet Encke during 225 years of its observational interval. Although the model with significant non-volatile mass contains less free values, it explains the characteristic features of the comet's non-gravitational parameters behavior better. The model can be further applied for the comet's observed astrometric positions fitting.

Keywords: Comet; Meteoroids; Meteoroid streams; Small bodies of the solar system; The orbits evolution

1. Introduction

According to modern theory, non-gravitational effects in comet motion are the result of reactive force action from cometary ice sublimation (Sekanina and Kracht, 2015). Therefore, it is quite natural that comet Encke, which has an exceptional combination of a small perihelion distance and a small orbital period, is the first comet for which non-gravitational effects have been observed. It is also the first comet for which secular changes of non-gravitational effects have been detected. However, the reasons for these changes are still the subject of discussion, impeding the construction of a unified comet motion theory (Maquet et al., 2012).

At the present time, for a mathematical description of the cometary non-gravitational forces, the "Style II" Marsden's model (Marsden et al., 1973) is the most widely used; this model describes sublimation change depending on heliocentric distance, but non-gravitational parameters, according to the model, characterizing the amplitude of this change, are constant. Usually 3–5 apparitions of comets can be linked by Marsden's model. The comet's motion representation is based on this partition in the JPL NASA "HORIZONS" service (Giorgini et al., 1996). Integrating the orbit that was obtained according to modern observations to the comet's discovery in 1786 via this service, the difference between the observed and calculated moment of the perihelion passage is 58.2 days. Integrating the orbit from 1786 to the present day, the error is up to 264 days. For the 1898 orbit, the deviations in 1786 and 2010 are 49.3 and 18.5 days, respectively. This is 3 orders greater than the inconsistencies, which can be explained by an orbital period determination error.

Initially, Marsden assumed that the parameters introduced by him were supposed to decrease exponentially with time (Marsden, 1969). The solution for comet Encke according to the 1947–1967 observations leaved 1.77″ root

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