ELSEVIER

CrossMark

Chinese Astronomy and Astrophysics 41 (2017) 347–356

CHINESE
ASTRONOMY
AND ASTROPHYSICS

The Effects of Geometrical Factors on Pulsar Rotation Parameters† ⋆

LI Liang[1,2△] WANG Guang-li[1] GUO Li[1]

[1] *Shanghai Astronomical Observatory, Chinese Academy of Sciences, Shanghai 200030*

[2] *University of Chinese Academy of Sciences, Beijing 100049*

Abstract This paper presents a detailed investigation of the effects of geometrical factors on pulsar rotation parameters, for examples the Earth rotation parameter, precession-nutation model, pulsar velocity and acceleration relative to the solar system barycenter (SSB), and planetary ephemeris error. The relations of these factors with the pulsar rotation parameters are derived, and the magnitudes of the effects of these factors are estimated, assuming that pulsars have typical parameter values. The effects of the Earth rotation parameter and precession-nutation model are negligible at the current accuracy level of observation. As the effect of the planetary ephemeris error on the pulsar rotation parameters is much less than the rotation parameters themselves, so it is also negligible. The effect of pulsar radial velocity relative to the SSB is 4 orders of magnitude less than the pulsar period. However, the effects of the pulsar transverse velocity and radial acceleration on the period derivative are not ignorable, especially for millisecond pulsars, where they may dominate the observed value of period derivative.

Key words astrometry, pulsar: general, methods: analytical

1. INTRODUCTION

Pulsar is a kind of object whose rotation frequency has an extremely high stability, so the pulsar timing observation is widely applied to the astrometrical and astrophysical studies, such as the test of gravitation theory, the detection of gravitational wave, the establishment of pulsar time, the stellar evolution and Galactic structure, etc. Based on the pulsar timing observation may be acquired the rotation parameters of a pulsar, including the rotation

† Supported by National Natural Science Foundation (U1431117)

Received 2016–01–27; revised version 2016–03–11

⋆ A translation of *Acta Astron. Sin.* Vol.57, No.5, pp. 560–567, 2016

△ lli@shao.ac.cn

doi:10.1016/j.chinastron.2017.08.005

period (P) and its derivative ($\dot{P}$). As they are the cardinal ones of pulsar parameters, the pulsar rotation parameters play a very important role in the study of the pulsars intrinsic nature and evolution, for example the determination of pulsar age, and so on. Thanks to the high stability of the variation of pulsar rotation frequency, the approximate age of a pulsar, which is known as the characteristic age of the pulsar ($\tau_{\rm c}$), may be estimated according to the rotational period and its derivative as follows:

$$\tau_{\rm c} = \frac{P}{2\dot{P}}\,. \tag{1}$$

Meanwhile, because of the correlation between the variation rate of the pulsar's rotation and its magnetic field strength ($B_{\rm s}$), the latter can be estimated from the pulsar period and its derivative as follows [1]:

$$B_{\rm s} = \sqrt{\frac{3c^3 I}{8\pi^2 R^6 \sin^2\alpha} P\dot{P}} \approx 3.2\times 10^{19}(P\dot{P})^{\frac{1}{2}} \ \ {\rm Gs}\,, \tag{2}$$

in which c is the light velocity; I, R and α, the rotational inertia, radius and magnetic inclination of the pulsar, respectively. Assuming that the parameter of the 2nd-order variation rate of the pulsar rotation period may be acquired, the braking index (n) of the pulsar can also be obtained from the rotation parameters as follows:

$$n = 2 - \frac{P\ddot{P}}{\dot{P}^2}\,. \tag{3}$$

In the pulsar timing observation there exists a difference of the obtained pulsar rotation parameters from the intrinsic ones. The pulsar rotation parameters obtained from the timing observation include the observational effects besides the intrinsic part of the pulsar itself, hence a certain deviation may be caused by using the pulsar rotation parameters obtained from timing observations in the study of the pulsar's proper nature. In previous researches, the effects of the variation of angular velocity in the earth rotation [2], the differential rotation of the Galaxy [3] and the precession [4] on the pulsar parameters have been studied respectively. Besides these effects, some geometric factors also cause the distortion of pulsar rotation parameters, including the pulsar velocity and acceleration relative to the solar system barycenter (SSB), and so on. It is helpful to analyze the effects of these factors on the pulsar rotation parameters for our knowledge of the pulsar's proper rotation property, and furthermore of the physical properties of the pulsar itself.

In this paper, are analyzed the relations between the pulsar rotation parameters and the geometrical factors, such as the errors of the earth rotation parameters, the pulsar velocity and acceleration, and the planetary ephemeris error, and the magnitudes of the effects of these factors on the pulsar rotation parameters are estimated. In the second section of this paper, the formula derivation and theoretical analysis are given. In the third section, the effects of different factors on the rotation parameters are analyzed. Finally, the discussion and conclusion of the analyzed results are given.