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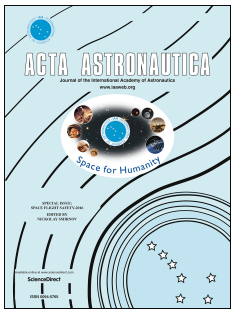

A new explorer mission for soft X-ray timing - Observation of the Crab pulsar

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A new explorer mission for soft X-ray timing - Obeservation of the Crab Pulsar

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Abstract – We discusse the current X-ray observation results of Crab pulsar obtained with the Time-resolved soft X-ray spectrometer, X-ray pulsar navigation 1 satellite launched on Nov. 10, 2016, summarize the 162 observations of the TSXS from MJD 57709 to MJD 57872, and introduce the propositional method of data reduction. We compare these observation results in the 0.5-9.0 keV energy band with the radio timing parameters by folding the profiles with radio timing ephemerides derived from Jodrell Bank and estimating the phase delay results. The statistical error of post fit time correction is 55.94 μs (root mean square). These achievements verify the effectiveness of the Time-resolved soft X-ray spectrometer and laid the foundation of the future work of the X-ray pulsar navigation 1 mission.

Index Terms –*X-ray Observation; Crab pulsar; timing correction; data reduction method*

1. INTRODUCTION

The X-ray pulsar navigation 1 (XPNAV-1) satellite is the first step[1] operated by the China academy of space technology (CAST) to demonstrate the X-ray pulsars navigation[2, 3] technique. This 270 kg small satellite was launched on Nov. 10, 2016 by the Long March 11 rocket at the Jiuquan satellite launch centre to the 500 km LEO orbit. It works at the three-axis stabilization mode with the ability to quickly point to any inertial position as accurate as 2 arcminutes according to demand, and to provide up to 90minutes sustained observation on any target with the consider of satellite power balance.

The purpose of the one-year XPNAV-1 mission is to test the technology of pulsar observation in the soft X-ray band through the X-ray instruments developed by CAST. Three objectives are outlined: (1) Test function and performance for the X-ray instruments in the outer space; (2) Detect typical X-ray pulsars' radiation photons and acquire the pulse profiles to verify the ability of X-ray pulsar observation. (3) Accumulate X-ray data for a long time to measure the pulsars' parameters via X-ray timing, and then explore the pulsar navigation method on ground. More information would be found in [1].

The XPNAV-1 satellite operates two X-ray instruments to compare different technological approaches for future X-ray pulsar navigation X-ray instruments. One is the Time-resolved soft X-ray spectrometer (TSXS), and the other is the high time-resolution photon counter (HTPC). The TSXS uses a Wolter type 1 lens of four nested mirror shells with the effective collecting area of around 10 cm^2 to focus X-ray photons within 15 arcminutes field-of-view onto a silicon drift detector (SDD). A GPS calibrated Rb clock is included to provide time information and a quasi-parallelly optical star is used to provide the detail difference between the TSXS observation aiming and the target pulsar direction. The TSXS device provides the 1.5 μs time resolution and the 180eV@5.9keV energy resolution in the 0.5~10 keV energy band. The HTPC servers as the designed primary experimental X-ray navigation detector, which uses the collimator to confine the field-of-view to 2 degrees and the micro-channel plate (MCP) X-ray detector to count the X-ray photons in the 1~10keV energy band from the pulsar. Compared to the TSXS, the MCP of the HTPC has a higher time resolution of 100 ns and a bigger effective collecting area of 1200 cm^2.

In order to examine the satellite-borne device of the XPNAV-1, we choose the PSR B0531+21[4,5] (Crab) as the calibration target because that this pulsar is believed to be one of the best studied objects in the sky, and one of the brightest X-ray sources regularly studied[6]. In this paper, we will present the current result of the TSXS observation on Crab. The original data analyzed here has already published on internet freely[16], any one are welcome to download the date for their research.

We arrange the paper as follows: the detailed description of the observations is given in Sec. 2. The summary of the data analysis is described in Sec. 3. Moreover, current results of Crab pulsar's timing results are provided in Sec. 4.

2. OBSERVATIONS

The observation presented here is composited by 162 missions target at PSR B0531+21 from 19 November 2016 to 28 February 2017 (MJD 57709 to MJD 57872) The designed duration of each observation is about 3000s.There are two sections in this time span. The first is before Dec. 28, 2016, which was the TSXS testing and calibrating period, and we arranged average six missions per day. The second starts from Dec. 28, 2016, and average one mission was arranged to save time for HTPC calibration.

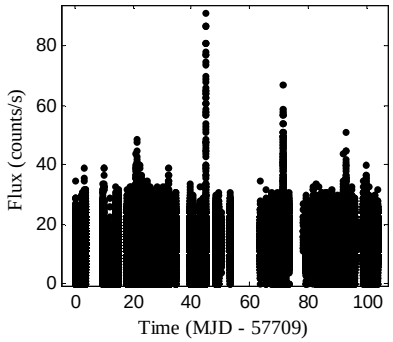

Fig. 1 Measure PSR B0531+21 photon flux between MJD 57709 and MJD 57872.

Each observation of XPNAV-1 is chosen to avoid the SAA region [7], and the angle between the Crab and the sun as well as between the Crab and the moon is larger than 45°to avoid the X-ray photon from these objects affecting the pulsar observation. The satellite performs aiming operation seven minutes before each observation mission to ensure the observation integrity.

3. DATA REDUCTION AND ANALYSIS

Before the data analysis, the data reduction should be applied to remove disturb interference caused by TSXS fault.