EPSC Abstracts
Vol. 6, EPSC-DPS2011-614-1, 2011
EPSC-DPS Joint Meeting 2011

Search For Small Trans-Neptunian Objects Using COROT Asteroseismology Lightcurves

Chih-Yuan Liu (1,2), Alain Doressoundiram (1), Françoise Roques (1) Michel Auvergne (1) Hsiang-Kuang Chang (2)
(1) Observatoire de Paris, LESIA, Meudon, France, (2) Department of Physics, National Tsing Hua University, Hsinchu, Taiwan (chihyuan.liu@obspm.fr / Fax: +33145077144)

Abstract

Trans-Neptunian Objects (TNOs) are the historical witnesses of the early Solar System and can provide astronomers much valuable knowledge about their formation and dynamical evolution. The current understanding of their properties, however, such as the total mass, orbital parameters and the sizes distribution, is still far from complete.
Here we will present a study of re-examination of COROT asteroseismology lightcurves for the search of small TNOs. The total observation time available in this work is about 144408.3 star-hours. We will analyze these fast photometry lightcurves data to search for serendipitous occultations by passing TNOs. Occultation method is a powerful tool to detect small Solar System bodies through their diffraction phenomenon[1]. The method of occultation will allow revealing the existence of TNOs that have sizes about several kilometers.

1. Introduction

1.1. Objective

The direct observation for TNOs is only possible for larger objects with diameters above several tens of kilometers. Small TNOs could only be found when they obscure background stars. Since occultations for these invisible objects are not predictable, the blind search for occultations in lightcurves of monitored stars may be possibly useful. We will apply this method to COROT asteroseismology data for the detection of small TNOs.

1.2. COnvection, ROtation & planetary Transits

COROT was launched on December 2006. Its two major goals are to search for extrasolar planets and to perform asteroseismology by measuring solar-like oscillations in stars. For our purpose, we will only use asteroseismology data, which has the integration time of 1 second. COROT has a polar inertial circular orbit (90-degree inclination) at an altitude of 896 kilometers. The apogee and perigee are respectively 911 and 888 kilometers. The orbital period is 6184 seconds. Twice a year, when the Sun gets closer to the orbit plane and is about to blind the telescope, the spacecraft performs a reversal attitude maneuver, dividing the year into two 6-month periods of observation (by convention, summer and winter). There are four observing runs (alternately 20 and 150 days) for a year.

2. Data Processing

2.1. COROT Asteroseismology N1 Data

Currently we have 165 COROT asteroseismology N1 lightcurves from 79 stars monitored within 9 observation runs. The visible magnitudes of those stars are from 4.77 to 9.48. The corresponding run-codes and accumulated observing time of these 9 observation runs are shown in Table 1. The longest lightcurve is about 131.5 days and the shortest one is only 411 seconds. The integration time of these data sets is 1 Hz. The information about the "cause of the rejection" (OVER) is included in the binary table of the lightcurve. The value of OVER indicates the status of the measurement. For our data reduction, we choose the bins with the value of OVER equals zero only. 'OVER = 0' means that data within this 1-sec bin-size is not affected by crossing SAA, energetic particle impacts, glitches or other status changing of the satellite.

2.2. Search Algorithm

The algorithm we used here is very similar with the method applied to the search of TNO occultation in X-rays[2]: we derived the deviation distributions for all COROT AN1 lightcurves, set the search criterion and looked for the outliers. The steps of our search algorithm are described below:

1. Estimate the deviation: For each bin of a lightcurve, we apply a 180-sec running window on it and calculate the statistic values of the intensity of star. We then reinterpret the intensity in the unit of standard deviations instead of the electron numbers in order to plot the deviation distribution.

2. Set criterion: As a first try and according to the behaviors of deviation distribution in Figure-1. we try to find the bins which have the negative deviation larger than 6.5σ.

3. Examine the reality of dips: Not every dip we found will be due to an astronomical occultation. For example, if the dip could be found at the same epoch in other lightcurves, it will be an artificial event due to occurring in the terrestrial environment (airplane, satellite, seeing effects etc.)

Table 1: COROT ASTEROSEISMOLOGY N1 DATA EMPLOYED.

$RunCode$	$DateStartEnd$	$ExpTime$
$IRa01$	$01/31 \sim 04/02, 2007$	12455.77
$SRc01$	$04/11 \sim 05/09, 2007$	5799.25
$LRc01$	$05/11 \sim 10/14, 2007$	33460.73
$LRa01$	$10/18 \sim 03/03, 2008$	28665.71
$SRa01$	$03/05 \sim 03/31, 2008$	5422.20
$SRa02$	$10/08 \sim 11/12, 2008$	7450.72
$LRa02$	$11/13 \sim 03/11, 2009$	25137.60
$LRc03$	$04/01 \sim 07/02, 2009$	9813.25
$LRa03$	$10/01 \sim 03/01, 2010$	16203.11
	$Total\ ExpTime(Hours):$	144408.31

3. Discussion

In our current COROT data search, there are 10^9 1-sec bins, and the random probability for -6.5σ is about 1.4×10^{-2}. We got a few bins below -6.5σ. The reality examination of those dips are still ongoing.
The Figure-2 gives the size distribution of objects in which is plotted the last estimates of Schlichting from HST data[3]. In this plot, we assumed we had no detection, so our null detection eliminates any power-law size distribution steeper, setting a stringent upper limit to the number density of TNOs. We are very close to the estimate of Schlichting thus making us hope for positive detections in those possible dip events we found and the upcoming COROT data.

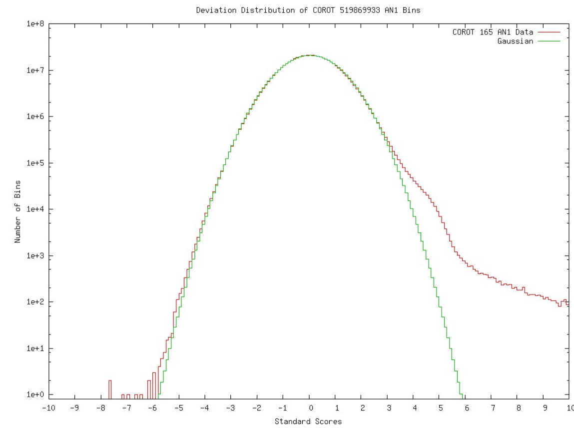

Figure 1: The deviation distribution of all bins employed in our work.

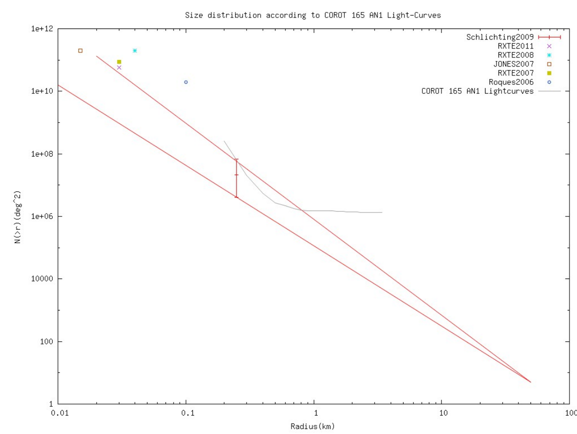

Figure 2: The comparison of our integrated upper-limit to Schlichting 2009 HST result.

References

[1] Roques et al.: Exploration of the Kuiper Belt by High-Precision Photometric Stellar Occultations: First Results, The Astronomical Journal, Vol. 132 pp. 819, 2006.

[2] Hsiang-Kuang Chang, Chih-Yuan Liu and Kuan-Ting Chen: Millisecond Dips In The 2007–09 RXTE/PCA Light Curve Of Sco X-1 And One Possible Occultation Event, Monthly Notices of the Royal Astronomical Society, Vol.411 pp.427-434, 2011

[3] Schlichting, H. E. et al.: A single sub-kilometre Kuiper belt object from a stellar occultation in archival data. Nature, Vol 462 pp. 895, 2009.