Discovery of sub-kilometer size Trans-Neptunian objects with the COROT space observatory.

A. Doressoundiram[1], C.-Y. Liu[1,2] and F. Roques[1] [1]*LESIA, Observatoire de Paris, CNRS, UPMC, Université Paris-Diderot, 5 place Jules Janssen, 92195 Meudon, France*, [2]Department of Physics, National Tsing Hua University, Hsinchu, Taiwan.

Introduction: Our approach is to use fast stellar photometry for serendipitously monitoring the occultation events caused by small (D ~1 km) Trans-Neptunian Objects (TNOs) located at the distance of 40 AU and beyond from the Sun, the so-called Kuiper Belt. Because of the small angular size of the star, the passing TNO through the line of sight of the star will produce a diffraction- dominated phenomena. For observations at opposition, the duration of the event is dominated by the Earth's movement and is rapid of the order of second or less. Serendipitous occultations have no other competing methods, as the magnitudes of the corresponding objects, V ~ 35 or fainter, are unreachable through classical ground-based imaging [1]. Such occultations reveal the vertical and radial distribution of the TNOs as far as 40 AU and beyond. Also, they provide information on the size distribution down to hectometer-sized objects. This is a key parameter for better understanding formation processes in this remote region of the solar system. In particular, the primordial structure of the proto-planetary disk just outside the giant planet region has been deeply modified by planetary migrations, resonance trapping and collisions ([2], [3]).

Corot data: COROT (COnvection, ROtation & planetary Transits) is a French satellite launched in 2006 and dedicated to the detection of transits by exoplanets. We re-examine the COROT asteroseismology lightcurves for the search of small TNOs. The total observation time available in this work is about 144408.3 star-hours. We analyze these fast photometry lightcurves data to search for serendipitous occultations by passing TNOs.

Data analysis: The data sample consists of 165 COROT asteroseismology lightcurves from 79 stars monitored within 9 observation runs. The visible magnitudes of those stars are from 4.77 to 9.48. 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 detection algorithm consists of searching in a running window any deviant points. For this purpose, we build the deviation distribution for all COROT lightcurves, set the search criterion and looked for the outliers. We express this histogram in unit of standard deviations and analyse events deeper than 6.5σ (fig. 1).

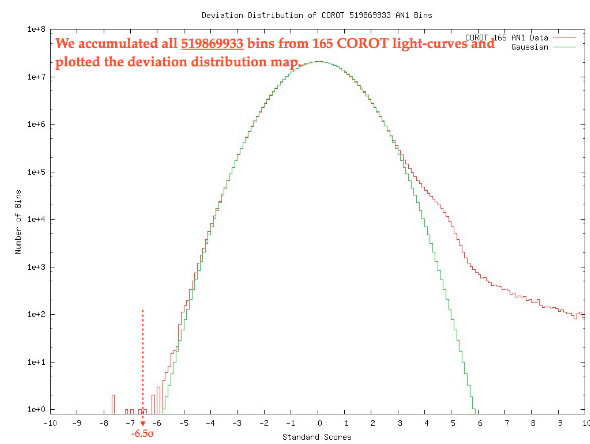

Figure 1: Deviation distribution of all the 10^9 1-sec bins used in our work

We have run several checks to assess the validity of our detections, such as checking the housekeeping data of the satellite, monitoring others stars observed at the same epoch, or test any strange correlation with physical/geometrical parameters.

Results: 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 obtained 15 possible events. Estimated sizes at 43AU range between 0.5 to 1.5 km. In Figure 2, we show the cumulative size distribution of TNOs. Our positive detections are plotted in grey, together with other lower limits detections founded in the litterature. The only positive detection is the Schlichting's one [4] giving a slope for the size distribution of q=3.9±0.3. Our own estimate, based of the fitting of 15 points, q=4.3±0.3, is in very good agreement.

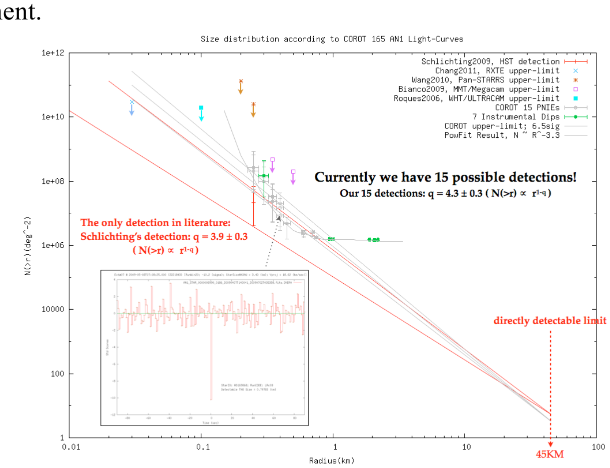

Figure 2: Cumulative size distribution of TNOs, according to the 15 possible detection found in the COROT data. The insert figure show one of them, a 10.2 significant dip.

Conclusions: Based on the analysis of 144408.3 star-hours of fast photometry lightcurves data, we have found 15 possible detections. This is the first time such large number of detection is reported. This allow us to constrain and give the size distribution of Trans-Neptunians Objects.

References:

[1] Roques F. et al. (2008) In The Solar System Beyond Neptune (eds. Barucci, Boehnhardt, Cruikshank & Morbidelli) University of Arizona press, 545-556. [2] Morbidelli A. et al. (2008) In The Solar System Beyond Neptune (eds. Barucci, Boehnhardt, Cruikshank & Morbidelli) University of Arizona press, 275-292. [3] Farinella P. et al. (2000) Protostars and Planets IV , University of Arizona Press-Tucson, 1255-1282. [4] Schlichting, H. E. et al (2009) Nature, Vol 462, 895.