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RECON – A new system for probing the outer solar system with stellar occultations

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Abstract

The Research and Education Collaborative Occultation Network (RECON) is a new system for coordinated occultation observations of outer solar system objects. Occultations by objects in the outer solar system are more difficult to predict due to their large distance and limited duration of the astrometric data used to determine their orbits and positions. This project brings together the research and educational community into a unique citizen-science partnership to overcome the difficulties of observing these distant objects. The goal of the project is to get sizes and shapes for TNOs with diameters larger than 100 km. As a result of the system design it will also serve as a probe for binary systems with spatial separations too small to be resolved directly. Our system takes the new approach of setting up a large number of fixed observing stations and letting the shadows come to the network. The nominal spacing of the stations is 50 km. The spread of the network is roughly 2000 km along a roughly north-south line in the western United States. The network contains 56 stations that are committed to the project and we get additional ad hoc support from the International Occultation Timing Association. At our minimum size, two stations will record an event while the other stations will be probing for secondary events. Larger objects will get more chords and will allow determination of shape profiles. The stations are almost exclusively sited and associated with schools, usually at the 9-12 grade level. We have successfully completed our first TNO observation which is presented in the compainion paper by G. Rossi et al (this conference).

1. Introduction

The normal methodology used for many decades in the occultation community is to strive for a ground-track prediction of the shadow path that is accurate enough to permit placing mobile stations in the shadow. This method imposes a requirement that the prediction of the relative position of the star and occulting body be known on a scale comparable to the size of the body. Meeting this requirement is not difficult for main-belt asteroids (MBAs). At 1 AU, the scale on the plane of the sky is 725 km/arcsec. Using a notional size of D=100 km (roughly $H_V = 9$) at a geocentric distance of 1 AU, a differential astrometric precision of 0.14 arcsec will produce a prediction where the error is equal to the size of the object. The astrometric precision required gets linearly smaller with increasing geocentric distance. Thus, a TNO at 40 AU would require a precision of $\sim$4 mas to get the same predictive knowledge of the ground-track. Getting such an accurate prediction can be done but is at the level of the best ever done and requires a substantial effort on large telescopes for each prediction.

By increasing the size of the network we relax the requirements on the astrometric precision needed for a successful observation. Figure 1 shows a map of the network of communities in the western United States that have been recruited and trained to collect occultation lightcurve data. One consequence of this design is that few stations will see any event but all stations will probe for additional material near the primary object. This system will be especially powerful for providing constraints on very close binaries and rings.

2. Instrumentation

The standard equipment provided is an 28-cm computer-controlled alt/az telescope (Celestron CPC1100). This system is very easy to assemble and align to the sky. Once aligned, the system can point to a desired target to a region just a little larger than the camera FOV. The video camera is made by MallinCAM and is specially designed to permit integrating on the target up to 2.1 seconds while maintaining a standard NTSC video signal. Timing data is provided by the IOTA-VTI GPS-based unit that superimposed time information on the video coming

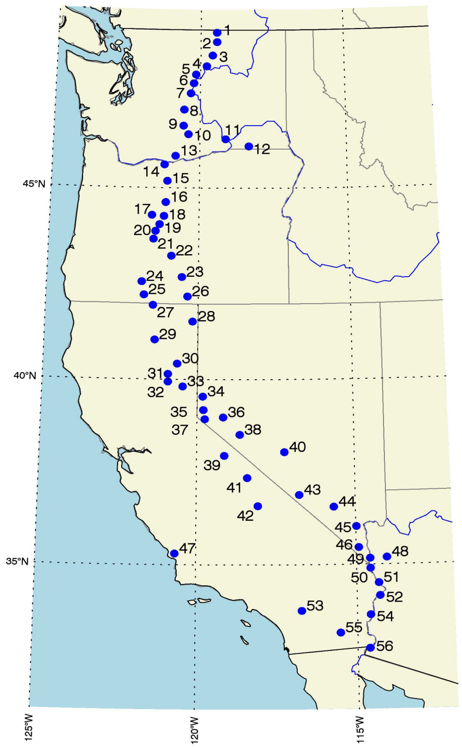

Figure 1: Map of the RECON sites.

from the camera. The data are collected on a small laptop computer with a video frame grabber. All of the equipment, except for the laptop, is powered from an external 12V battery pack. The combined cost of a single station is roughly $5000. This system can collect useful data on stars as faint as R=16.5.

3. Predictions

To support the project, we are building an automated TNO occultation prediction system. The system looks for events anywhere on the Earth but also generates special topocentric supporting information for events within reach of RECON. All of these predictions are to be made public to encourage participation from other un-affilated teams. Many of the targets we are chasing are rather faint, requiring special effort to collect additional astrometry with 4-m class telescopes. Most of the recent successes with TNO occultations have largely been for objects within reach of 2-m class telescopes.

4. Observations to Date

Observations by RECON began in May 2012 with the pilot team sites. Nearly 40 events, mostly with main-belt asteroids, were attempted and most were successful. Included these observations were participation in a campaign on Jupiter Trojan Patroclus[1]. Our first TNO event was in Nov 2014 of (229762) 2007 UK_{126} (see presentation by G. Rossi).

5. Summary and Conclusions

This new system wasfully implemented with the completion of training in April 2015 and is now ready to begin its exploration of the Kuiper Belt. The project is funded through 2019. Stastistical predictions suggest we will be able to get successful observations of 1-2 TNOs per year, including prediction uncertainties and losses due to weather. These data will provide new measurements of sizes of smaller TNOs and contrain the population of ultra-tight binaries in this primordial population.

Acknowledgements

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References

[1] Buie, M.W., Olkin, C.B., Merline, W.J. *et al.*: Size and Shape from Stellar Occultation Observations of the Double Jupiter Trojan Patroclus and Menoetius, Astron. J. vol 149, p. 113, 2015.