Census of the Kuiper-Belt Objects – The Taiwan-America Occultation Survey (TAOS)

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Abstract. More than two hundred transneptunian Kuiper-Belt Objects (KBOs) have so far been identified. Because of their large distances from the Sun, and their intrinsically small sizes, only the largest members (diameters more than 100 km) can be observed by direct imaging with large telescopes. Even smaller KBOs, though expected to be more numerous on theoretical grounds, cannot be seen directly unless they happen to block out the light from background stars. The Taiwan-America Occultation Survey (TAOS) project is a collaboration among the Lawrence Livermore Laboratory (USA), Academia Sinica, National Central University (both of Taiwan), and other institutes, that aims to measure the frequency of such chance stellar occultations, and thereby conduct the census of the Kuiper-Belt population down to a few kilometer sizes. An array of robotic telescopes are being set up in central Taiwan to monitor the brightness variation of several thousand stars at a rate of a few Hz. Observations will be operated in a synchronized and coincidence mode, so the sequence and timing of any candidate occultation event can be recorded and distinguished against a false detection. The full survey is expected to start in the fall of 2000.

1. The Kuiper-Belt Objects

The Solar System is believed to condense out of an interstellar cloud of gas and dust, in which the hot, central part collapsed to form what later became the Sun, whereas in the rotating circumstellar disk, solid grain particles continued to grow, and eventually coagulated to form planets and satellites. Impacts by remnant material played an important role in the early geological, atmospheric and even biological history of bodies in the Solar System.

The gas and dust were soon dispersed by solar wind, radiation, and by perturbation from giant planets. Icy, volatile-rich objects far from the Sun – despite their possibly large population – cannot be studied due to their small sizes and thus faintness, unless they happen to wander toward the inner Solar System and display cometary behavior.

More than two hundred transneptunian Kuiper-Belt Objects (KBOs) have so far been identified. These were seen by reflected sunlight, observed with large-aperture telescopes, thus would be biased toward the largest members. All the KBOs found so far have diameters larger than about 100 km. Even smaller

KBOs, though expected to be more numerous on theoretical grounds, are much too faint to image directly.

2.   The Taiwan-America Occultation Survey (TAOS) Project

A KBO may reveal its existence, nevertheless, if it happens to block out the light from a background star. The Taiwan-America Occultation Survey (TAOS) project, a collaboration among the Lawrence Livermore Laboratory (USA), Academia Sinica, National Central University (both of Taiwan), and other institutes, aims to measure the frequency of such chance stellar occultations, and thereby conduct the census of KBOs, especially toward the small sizes. Our observations are sensitive to objects down to a few kilometer sizes.

An array of 4 small (50 cm), wide-field (f/1.9) telescopes are being set up in central Taiwan (Lulin Observatory) at near 3,000 m elevation to monitor the brightness variation of several thousand stars at a rate of a few Hz. Each telescope is equipped with a 2K-squared AP-10 CCD. These robot telescopes will operate in a coincidence mode, so that the sequence and timing of any candidate occultation event can be recorded and distinguished against a false detection.

The first telescope was installed in April 2000, and the rest three will follow in the fall/winter. The full survey will start thenceforth. In addition to detection of KBO occultations, our project will collect large amounts of data – some 10,000 GB worth of rapidly sampled photometrical measurements each year. Other scientific byproducts, notably variable stars, will conceivably spin off from this database.