# The Potentially Hazardous Asteroid (2102) Tantalus

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The asteroid (2102) Tantalus, discovered by C. Kowal at Palomar in 1975, is a little more than a km across and is on a highly inclined (64° to the ecliptic) orbit that passes only 0.043 AU from Earth, less than the 0.05 AU limit for potentially-hazardous near-Earth asteroids (NEAs). With the very high inclination, if it struck the Earth, it would do so with a very high velocity, causing serious worldwide damage to human civilization. Fortunately, numerical integrations of its orbit show there will be no very close encounters with Earth during the next 1000 years, but the orbit is not known well enough to say what the chances are beyond that.

As explained in a paper pressented at the 2021 Planetary Defense Conference (PDC) available at [http://iota.jhuapl.edu/NEOoccultationsDunham.pdf](http://iota.jhuapl.edu/NEOoccultationsDunham.pdf), observations of occultations of stars by NEAs provide a powerful method for determining the accurate orbits of NEAs, especially when used in conjunction with radar observations, to assess the threat of NEAs far into the future. If the occulted star is bright, the NEA occultation can be recorded with small telescopes. Last May 7$^{th}$, we had such an opportunity with Tantalus, when it occulted an 8.4-mag. SAO 164452 (= HIP 106281) in a path crossing s.w. Oregon to s. Texas, as shown in the map at the top of p. 2 of [https://occultations.org/publications/rasc/2023/nam23NEAoccs.pdf](https://occultations.org/publications/rasc/2023/nam23NEAoccs.pdf) .

Ted Blank, Norm Carlson, and we decided to try the occultation. Clouds were predicted for most of the path, but clear skies were forecast for central New Mexico, so we converged on Socorro, NM, near the path, the afternoon before the occultation. Ted Blank and we used 8cm "mighty midi" systems, like those used for the successful first Apophis occultation observations shown in figures 8 and 9 of p. 10 of the PDC 2021 paper; Norm Carlson used a 20cm SCT. Norm, with the larger scope, observed from the predicted central line, shown with the green line in Fig. 1. Ted set up his stations on the 5 parallel yellow lines, spaced 1 km apart on the sky plane and projected only slightly more on the ground, extending southwest from center, while we set up on those extending to the northeast. The first of the yellow lines in both directions are almost coincident with the blue limit lines. This way, we were able to cover most of the "1-sigma" path error range between the two red lines on the map where the occultation was most likely to occur. The predicted size of Tantalus was 2.1 km, so we thought this strategy would provide two positive chords with high confidence. Norm tracked the target star, while all of the stationary "midi" systems were pre-pointed to the altitude and azimuth of the occultation using stars and relying on the Earth's rotation to bring the target into the field of view at the right time. This worked for all stations except Ted's southernmost (farthest from center) station, where the battery of the laptop used to record the occultation there died before the event. As Fig. 2 shows, only Norm had an occultation; that provides an astrometric point accurate to about a km in the sky plane that will greatly improve the accuracy of the current orbit and allow it to be propagated farther into the future for checking for possible collisions. It will also allow good predictions for occultations during the next few years so that the next Tantalus occultation can be observed from two or more stations, which will allow decreasing the orbital errors by another order of magnitude. The next chance for radar observations won't be until 2038.

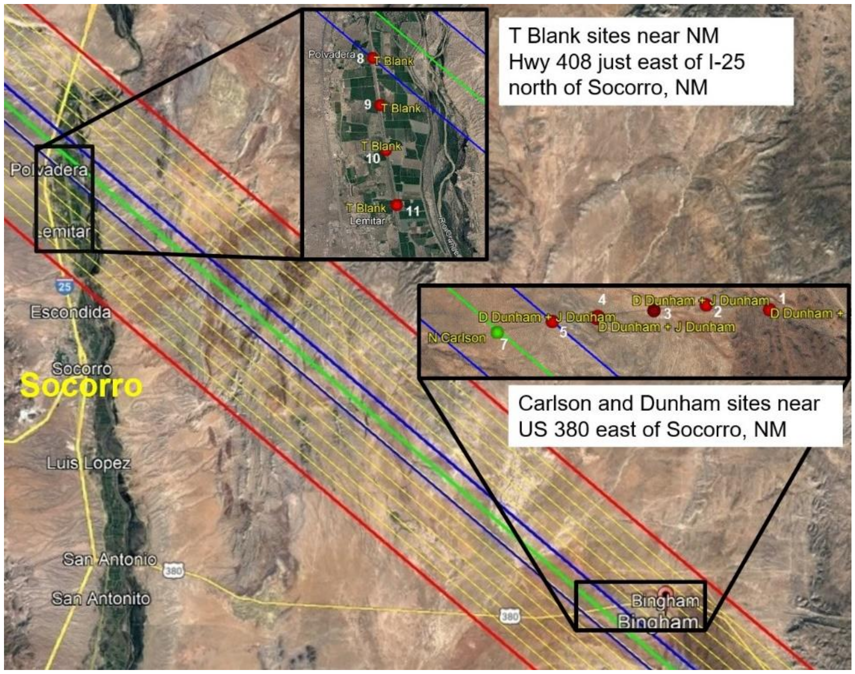

Fig. 1. Observation sites for the 2023 May 7 occultation by Tantalus in the Socorro, NM area. The station numbers are the same as those used in Fig. 2. Image credit: David Dunham and Norm Carlson, IOTA.

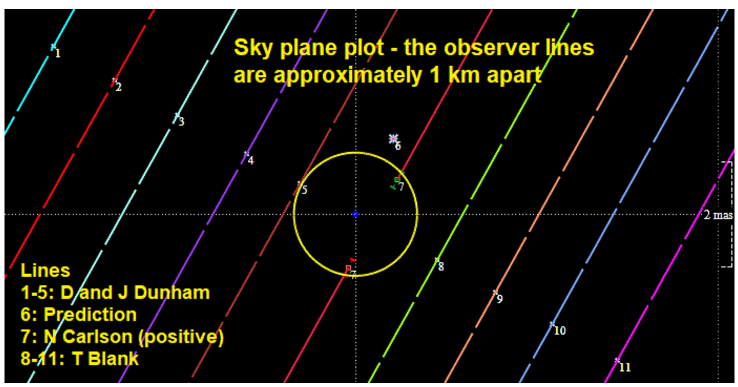

Fig. 2. Sky plane plot of the observations of the 2023 May 7 occultation by Tantalus. Image credit: David Dunham and Norm Carlson, IOTA.

After the occultation, I discovered online a paper about Tantalus, published only last year in M.N.R.A.S. (Rożek et al., Vol. 515, pp. 4551-4564, 2022) that gives the relable radar diameter to be 1.4 ±0.2 km. If we had known that before the event, we would have used a smaller spacing between stations, to increase the chances for two positive chords with the smaller size. We also should have expected the prediction to be more accurate than the formal errors indicated, which was the case for another NEA occultation by the larger NEA, (1866) Sisyphus, successfully observed near the central line by just one observer, Steve Messner, in November last year. A better strategy would have been to space the 4 or 5 inner stations only a quarter of the asteroid's diameter apart, then the others about 0.7 diameters apart; that would have resulted in 3 or 4 positive chords with a good prediction, and likely one chord for a poor prediction.