

Observing large trans-Neptunian objects and a dwarf planet around their stationary points – a K2/C2-C3 proposal

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Context. The outer Solar System is characterized by mostly small, icy objects, orbiting beyond Neptune. Trans-Neptunian objects (TNOs) are likely to be remnants of outer Solar System planetesimals [1]. Their physical, chemical, and dynamical properties should therefore provide valuable information regarding both the environment and the physical processes responsible for planet formation. The physical properties of TNOs, such as their shapes, densities, and albedos, are poorly constrained. The study of TNO rotational properties through time series broadband optical photometry is proved to be the most successful technique to date to investigate some of these physical properties [3]. TNOs move slowly, therefore they could be ideally observed with Kepler for long time intervals during the K2 Mission. In this C2-C3 joint proposal we argue to observe three TNOs accessible to K2 to perform a photometric analysis with an unprecedented precision and duty cycle.

Scientific justification. We propose two relatively bright TNOs in Field2 (119951 2002 KX14, and 2007 JH43) and a moderately faint TNO in Field3 (225088 2007 OR10), all for long-cadence observations. All three objects were observed with the Herschel infrared space telescope. These objects represent outstanding examples for the three most significant dynamical TNO classes. The predicted magnitudes are $V=20.5$, $V=21.0$ and $V=21.5$, respectively. The estimated K2 photometric precision is 0.18, 0.27, 0.45 mag for 30 min. Therefore, the precision in the amplitude and shape elongation determination will be in the order of 3-5% during the entire run that lasts for several 10 days. **225088 2007 OR10** is a dwarf planet in the scattered disk, currently it is the second-farthest known large body in the Solar System, at a distance of ~ 87 AU. It is among the largest and intrinsically brightest TNOs. This dwarf planet candidate is one of the reddest TNOs known, most probably due to the presence of a space-weathered methane layer. Herschel observations resulted in an effective diameter of 1280 ± 210 km and a V-band albedo around 14%, suggesting the presence of bright spots of frozen-out gases (water and/or methane). Thus the K2 light curve may reveal surface albedo variations. Cryovolcanic activity is also hypothesized, that could continuously re-create the high reflectivity areas that would otherwise turn dark with time due to space weathering. **119951 2002 KX14** has the smallest inclination (0.4 deg) among the hot classical TNOs, with a diameter of 450 km [5]. **225088 2007 JH43** is a Plutino. It is dynamically unstable on a few million year time scale, because of its unusually low eccentricity (0.03).

Our immediate goals in all three cases are (1) Finding the rotation period from the photometric data. The faster the rotation, the more accurate the period determination will be. **(2)** Reconstructing regions of different albedo. The inhomogeneity of the surface would shed light on the process(es) that change the albedo **(3)** More than 20% of the classical trans-neptunian objects have moons that are usually comparable in size with the main objects [4]. Our proposed observations might reveal the presence of companions, that has not been possible by any other ground based observation before.

K2 observations and technical issues. We determined the pixel cost of K2 observations of a minimum of 40-days orbital arc for the three objects. We assumed 5-5 pixel puffer zone along the orbital arc in each case. **Field2: (119951) 2002 KX14** ($V=20.5$) will be on silicon during the total C2 observing period. At a cost of 500 pixels 60 day observation is possible. **2007 JJ43** ($V=21.0$) will also be on chip during the C2 campaign. Allocating 500 pixels is enough to follow the object for 40 days. **Field3: (225088) 2007 OR10** ($V=21.5$) moves between CCD modules for half of the time, it is observable for 8 days at the beginning of the observing campaign, then for ~ 30 days around its stationary point. An estimated total of 400 pixels in two 'superapertures' are required to cover the 8- and 30-day observable arcs.

Remarks. Further scientific justification and technical details are available in our K2 TNO White Paper (Trans-Neptunian objects with K2: targeting our own Solar System) [2]. We note that due to the unusual requirements of the moving targets we give coordinates for each objects instead of a conventional target list in the accompanying spreadsheet documents. The coordinates were computed for a Kepler-centric coordinate system using NASA's Horizons tool¹ with a time step of one day which should facilitate the allocation of pixels if the proposal is selected.

References

- [1] Jewitt & Luu 1993, Nature, 362, 730
[2] Kiss et al. K2 TNO White Paper, 2014
[3] Lacerda & Luu 2006, AJ, 131, 2314

- [4] Stephens & Noll 2006 AJ, 131, 1142
[5] Vilenius et al. 2012 A&A, 541, A94

1 <http://ssd.jpl.nasa.gov/horizons.cgi>