Proof-of-concept study to observe a trans-Neptunian object around the stationary point – a K2/C1 proposal

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Introduction. 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 [2]. 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 still poorly constrained. The study of TNO rotational properties through timeseries broadband optical photometry is proved to be the most successful technique to date to investigate some of these physical properties [3].

Proof-of-concept proposal. TNOs move slowly, therefore they could be ideally observed with Kepler for long time intervals during the K2 Mission. The slow motion is not a serious problem if ample number of pixels are allocated. However, the faintness of these objects makes their inclusion risky in the K2 Mission. Therefore we propose a pilot study costing a negligible number of pixels (~100) to test Kepler's capabilities in this faint magnitude regime. Here we propose to observe one faint trans-Neptunian object in K2 Field1 to test Kepler's precision at V=22 and demonstrate that it is viable to routinely observe these Solar System objects at a reasonably low pixel cost. This experiment would also shed light on the severity of stellar contamination, pointing jitter and other problems, and would allow us to polish our photometric algorithms. A white paper detailing the scientific justification and technical aspects is also submitted with this proposal. We estimate that at $V=22^m$ the photometric precision of a 30-min integration would be a few tenth of a magnitude. Here we only list a few science questions that we could target with this proof-of-concept study with limited length and scope.

Scientific justification. We propose one of the highest albedo (>19%), relatively small (<180 km) classical TNO [5,6]: 2002 GV31 for long-cadence observations in K2/Field1. **(1)** The photometric data will reveal the rotation period unambiguously. The faster the rotation the more accurate the period determination will be. **(2)** regions of different albedo could be reconstructed. The inhomogeneity of the surface would shed light on the process(es) that increased the albedo of this particular object. **(3)** $22^{+10}/_{-5}$% 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 a companion, which has not been possible by any other ground based observation before. In the case of a successful detection, 2002 GV31 would be the smallest TNO system for which the mass, and hence the density could be determined [1], serving as a very crucial example in testing these models.

Target. We choose **2002 GV31** (V=22) because it will reach its stationary point during the Field1 observing campaign (on 9 Jul as seen from the spacecraft), where its apparent speed will decrease to 0.9 pixel/day. We ask to allocate a single 10x10 pixel mask very near to the stationary point of this trans-Neptunian object. This way K2 will be able to observe 2002 GV31 for approximately 10 days. The coordinates of the center of the pixel mask should be (RA: 172.16119, DEC: 5.56642). We note that by using NASA's Horizons[1] portal we converted the coordinates to a spacecraft-centered coordinate system, which is important, because of the significant distance of Kepler from Earth at the time of the proposed observations. With this setup K2 would be able to observe 2002 GV31 as a **non-moving stellar object** without any modification to the pixel allocation algorithm. If additional pixels are available it would be easy to tailor our proposed pixel mask to allow monitoring this TNO for additional days/weeks during Campaign 1.

If selected, we offer our expertise to quickly evaluate 2002 GV31 data to leave ample time to consider and implement a *(slowly) moving target observing mode* in the K2 Mission. Such an observing program would greatly complement the principal goals of the main Kepler (and K2) Missions by opening new avenues to learn more about planetary system formation by studying our own Solar System.

References

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