Searching for distant rings of Neptune with K2 – a C3 proposal

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Context. The irregular satellite systems of the giant planets in our Solar System are collisionally evolved [1], and this evolution can manifest itself in the form of dust rings, typically at much larger distances from the planet than the usual, well-known ring system. An example for such a distant ring is the Phoebe ring of Saturn, discovered by the Spitzer Space Telescope [2]. Its material is originated from Phoebe and is continually replenished by micrometeoritic impacts. Similar ring-like features may be present in other giant planet satellite systems, e.g. in that of Neptune.

Scientific justification. The detection of these dynamical structures would help us to understand the formation of outer planets and their present-day dynamical interactions with their environment. A discovery would have ramifications for shaping our view on the recently discovered large sample of exo-Neptunes, as well. The detection of these rings is challenging due to their low surface brightness and relatively large apparent distance (several arcmins, or even further) from the central planet. Stellar occultations of these possible rings provide the best tool for their detections, but due to the unknown location of the rings many stars have to be monitored continuously and simultaneously around the planet investigated. This is a requirement, in addition to precise photometry, that only Kepler can fulfill. The best configuration for these occultation observations is at the opposition turnover of the planets as at this time they move with the lowest possible apparent speed allowing the detection of narrow rings. This is the case for Neptune in K2's C3 field.

Targets. To capitalize on the unique capabilities of the K2 Mission in finding these elusive structures around Neptune, we judiciously selected stars along the planet's path[1] in Field 3 (see Fig.1. and the attached prioritized list). We chose bright target stars (10<Kp<14) from the EPIC catalog to ensure high enough signal-to-noise ratio to detect occultations by the rings. As an optimal scenario **we ask 4 stars to be observed with short cadence.** These are strategically located targets along Neptune's path and will be inevitably occulted if outer rings are dense enough. The time resolution provided by the short cadence mode is crucial and will allow a detailed study of the structure of the otherwise unseen rings. As a minimum, SC observations are required for the first two of these stars. **45 other targets are proposed to be observed in long cadence mode.** These will be important to confirm the detection. These stars are expected to show only one outlier (fainter) point in their time series photometry, but the timing will be decisive and the fading of these stars at the right time will confirm the presence of a ring-like structure. We choose stars to be sensitive to detect ring(s) in a distance between about 30 arcseconds (set by the resolution of Kepler and the brightness of Neptune) to approximately one degree from the host planet. In the optimum case a single ring can cause up to four occultation events in a given star's light curve, as the planet moves back and forth on the CCD module. As a bare minimum, the first 12 LC targets are required for the success of this proposal. We note that other stars in the right distance range that will be selected for other proposals may be used for our purposes, as well. Conversely, any interesting object among our targets (solar-like oscillators, eclipsing binaries, etc.) will be also investigated in detail. It is estimated that the relatively bright Neptune will not have significant impact on the precision of the photometry at the relevant ring distances.

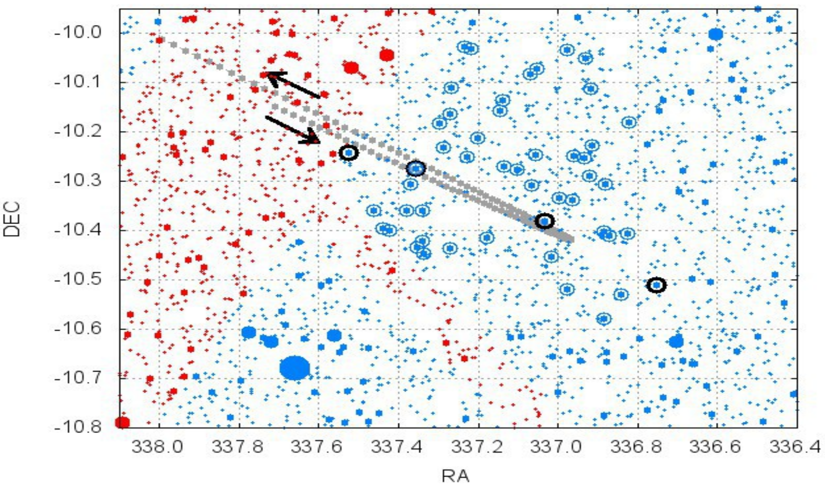

Fig 1. *Path of Neptune in Field 3 (gray points) as seen from Kepler. Small arrows show the direction of the planet's move. Blue points are stars that fall on silicon, red ones are not accessible for K2. Selected stars for short cadence observing mode are denoted by bold black circles, proposed long cadence targets are drawn with single blue circles. The size of the symbols denote stellar brightness (Kp, taken from the EPIC catalog).*

References [1] Kennedy & Wyatt 2011, MNRAS, 412, 2137 [2] Verbiscer et al., 2009, Nature, 461, 1098

1 To predict the path of Neptune as seen from the Kepler spacecraft, NASA's Horizons tool was used which is available at http://ssd.jpl.nasa.gov/horizons.cgi