High-Precision Eclipse Timings of Recurrent Nova U Scorpii

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Recurrent nova (RN) U Scorpii (U Sco) is the prototype RN, with ten known thermonuclear eruptions at fairly regular intervals of 10±2 years (Schaefer 2010), with the last being in 2010 (Schaefer et al. 2010). RNe must have a near-Chandrasekhar mass white dwarf and a very high accretion rate, with these two properties making it seem that the white dwarf must soon reach the Chandrasekhar mass and explode as a Type Ia supernova. With this basic logic, RNe have long been one of the favorite candidates as a solution to the very-long-lasting 'supernova progenitor' problem. The progenitor problem is recognized by the latest Decadal Review as one of the most important in all astrophysics, and this make the prototype RN as being of high importance.

So, can U Sco be a supernova progenitor? The basic logic in the previous paragraph has the loophole that the white dwarf ejects mass once every eruption cycle, so it is a question of balance as to whether the white dwarf is gaining or losing mass over the whole cycle. Unfortunately, all the standard methods for measuring the mass of the nova ejecta all have orders of magnitude uncertainty. But fortunately, I have pioneered a new method with high precision based on measuring the change in the orbital period from before and after the eruption (Schaefer 2011). For this, I have accumulated long time series photometry of U Sco on ~300 nights since 1987, with first the discovery of the U Sco eclipses (Schaefer 1990) and then the accurate measure of the pre-eruption orbital period (Schaefer et al. 2011). This massive work has measured the period changes across the 1999 and 2010 eruption, with the result being that the ejecta was more massive than the material accreted between eruptions. The ground-based O-C curve for eclipse times has large scatter on this critical issue of high importance.

Another open question that K2 can answer is whether the eclipse is total, with this being critical for the best distance measure (based on the brightness in deepest eclipse assumed to be the un-irradiated companion alone). My many ground-based light curves are too poor to tell if the bottom of the light curve is really flat. But K2 has the accuracy to precisely measure this. Also, if any edges of the disk stick out at mid-eclipse we can see the usual ~0.1 mag flickering, perhaps at a fraction of its normal rate. This can be turned around, and we can use the K2 light curve to map out the site of the flickering, with this never having been accomplished before. The flickering is on the time scale of minutes, so the 1-minute cadence is needed.

U Sco has a 1.23 day orbital period, with eclipse durations of 4 hours and the apparent totality lasting 45 minutes. With this, 30 minute integrations would only return poor eclipse timings, so 1-minute cadence is required. In the 88-days on Field 2, there will be 71 eclipses, with this being equal to my hard-fought collection since 1987. U Sco has V~17.5 and R~17.1 (Schaefer 2010), so it will usually have a photometric precision of around 0.02 mag for every short cadence measure. This will have greatly better time resolution and photometric precision than any of my ground-based U Sco light curves (except for one half-eclipse I took with the McDonald 102-inch). With the superb photometric precision, zero-gap coverage for 88 days, and 1-minute time resolution, the K2 mission will do greatly better than the world's full efforts for decades. U Sco is the key system in one of the biggest problems in astrophysics, and now K2 can get a wonderfully precise O-C curve for eclipses, measure whether the eclipse is total, and for the first time measure the site of the flickering by eclipse mapping.

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