

K2 Director's Discretionary Time proposal for Field 9

## **Discovering the Orbital Period of the Recurrent Nova V2487 Oph**

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Recurrent novae (RNe) are ordinary nova systems that have eruptions with a recurrence time scale of faster than a century. They are binary systems consisting of a white dwarf (WD) and relatively-normal companion star in which the WD accretes material from the companion until enough mass has accumulated on the surface of the WD that a thermonuclear runaway is triggered, which we observe as the nova eruption. To have multiple eruptions within 100 years, the WD must be near the Chandrasekhar mass and the accretion rate must be very high. These two conditions combine to make RNe prime Type Ia supernova (SN Ia) progenitor candidates, since at first glance it is likely that the WD will soon reach the Chandrasekhar mass and explode as an SN Ia.

For novae and RNe, the single most important system property is the orbital period (P). The period tells us both the accretion rate and the nature of the companion star, while P orders the photometric variations. For RNe, P divides the systems based on the mechanism for driving the high accretion rate, with the short-period systems being driven by high irradiation of the companion by a prior nova eruption (Schaefer, Pagnotta, & Shara 2010), and with the long-period systems being driven by the evolution of the companion star. The long-period RNe are almost unique amongst novae for having sub-giant companions (with  $P \sim 1$  day) or red giant companions (with  $P \sim 1$  year).

Only 10 RNe are known in our Milky Way (Schaefer 2010). The least known of these is V2487 Oph. This RN was first observed to erupt in 1998 with a peak at  $V=9.5$ , after which it faded by 3.0 mags in 8 days ( $t_3=8$  days), displayed a plateau, and thus is in class P8 (Schaefer 2010; Strope, Schaefer, & Henden 2010). With an intentional directed search, we discovered a prior nova eruption in the year 1900 on archival sky photographs, proving that V2487 Oph is an RN (Pagnotta et al. 2009). In quiescence, it is at  $V=17.3$  ( $B-V=0.8$ ), with fast variations of 0.1-0.6 mag amplitude on the ten-minute time scale (Schaefer 2010). No orbital period is known. We have used several runs at Cerro Tololo and McDonald observatories, but we have not been able to pull out any periodic photometric modulations, with the primary problem being the difficulty of getting adequate time coverage in the presence of the flickering. V2487 Oph certainly does not have a red giant companion star, because its spectrum does not show any of the usual prominent red-giant lines in the red, nor does its spectral energy distribution show a peak in the red. In a detailed model of the system, Hachisu et al. (2002) suggested that V2487 Oph is in the RN subclass with a sub-giant companion, hence with  $0.3 < P < 3.0$  days or so.

We propose V2487 Oph as a short-cadence target for K2 during Field 9. For 1-minute short-cadence integrations on the  $V=17.5$  star in quiescence, the uncertainty will be  $\sim 0.02$  mag. The reason for the short-cadence is that V2487 Oph is known to continually display variations of  $>0.1$  mag on time scales of ten minutes, and because we expect variations from eclipses or white dwarf spins to be much faster than 30-minutes.

Every other RN displays photometric variations on the orbital period. The causes of the periodic variations are eclipses, the ellipsoidal effect, the irradiation of the companion star, and the disk hot spot casting light in preferred directions. With the awesome cadence and sensitivity of *Kepler*, these periodic signals will be recognizable at all system inclination angles short of almost-exactly face-on. So it is very likely that *K2* will be able to discover the P for V2487 Oph.

In a very detailed analysis of the large number of archival plates that we have examined, we estimated that the true recurrence time of V2487 Oph is 18 years, with an uncertainty of ~20%. (Schaefer 2010). The last observed eruption was in 1998, so Schaefer (2010) explicitly predicted that the next eruption would be in the year 2016. The uncertainty on this predicted eruption date is ~3 years, of which the first half of the distribution is now gone. In the 0.3 years from now until the start of the Field 9 observations, there will be a ~10% chance that V2487 Oph will erupt. So at the ten-percent level, *K2* will catch V2487 Oph in the tail of a nova eruption. If so, then *Kepler* would get the first long-and-fast time series on a nova in eruption, and all with great cadence and accuracy. The only prior such light curve (for U Sco in 2010) had greatly poorer accuracy, yet giving the discovery of three unexpected and completely-new phenomena (Schaefer et al. 2011; Pagnotta et al. 2015). [Note: we have a *K2* DDT proposal for Field 9 to catch V5666 Sgr and V5667 Sgr, from 1-2 years after their peaks, with these being *guaranteed* cases of catching an ordinary nova late in their eruptions.] Also, there is ~10% chance that *K2* will have excellent and unique coverage of the first minutes of the nova explosion. Only once before has a nova been caught in the first day of eruption, within seven mags of quiescence, and for that case (T Pyx in 2011, see Schaefer et al. 2013) a poorly-sampled light curve showed a theoretically-inexplicable 'simmering' or failed-ignition in the days before eruption. In all, we have ~20% chance that *K2* will catch V2487 Oph during eruption, with uniquely wonderful coverage, and a good possibility of seeing new and mysterious phenomena.

Few RNe are known, and only those 10 RNe in our Milky Way can be studied in any real detail. With so few, it is extraordinary that *K2* will allow for detailed study of the least-known Milky Way RNe, and possibly catch it in eruption. V2487 Oph should be studied in its own right as a rare and interesting system. V2487 Oph must also be studied as an exemplar of a prominent and important candidate solution for the uber-important SNIa progenitor problem.

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