K2 Director's Discretionary Time proposal for Field 9 (due 10 December 2015)

Recurrent Nova V3890 Sgr

PI: Bradley E. Schaefer (Louisiana State University; schaefer@lsu.edu)
CoI: Frederick Walter (SUNY Stony Brook)
CoI: Ashley Pagnotta (American Museum of Natural History, New York City)

Recurrent novae (RNe) are ordinary nova systems that have eruptions with a recurrence time scale of faster than a century. They are binary systems where a relatively-normal star orbits close around a white dwarf, spilling matter onto the white dwarf through an accretion disk, where the mass accumulates until a thermonuclear runaway on the surface explodes as the nova event. To get a recurrence time scale shorter than a century, the white dwarf must be near the Chandrasekhar mass, plus the accretion rate must be very high. These exact two conditions, taken simplistically, mean that the white dwarf will soon reach the Chandrasekhar mass and blow up as a Type Ia supernova (SNIa). Indeed, this is the reason why RNe are one of the most popular ideas for the SNIa progenitor.

Only 10 RNe are known in our Milky Way (Schaefer 2010). One of the least known of these is V3890 Sgr. This RN erupted in 1962 and 1990, with an inter-eruption interval of 27.9 years. The eruption light curve peaks at V=8.1, fades by 3.0 mags from peak in 14 days (t_3=14 days), displays a plateau, and thus is in class P14 (Schaefer 2010; Strope, Schaefer, & Henden 2010). V3890 Sgr has an M5 red giant companion star. In quiescence, it is at V=15.5, with B-V=0.9, and we discovered the orbital period of 519.7 days from eclipses with a 1.0 mag amplitude (Schaefer 2009). In addition to the orbital modulation, the system shows a low-amplitude 103.8 day red giant oscillation.

We propose V3890 Sgr as a short-cadence target for *K2* during Field 9. For 1-minute short-cadence integrations on the V=15.5 star in quiescence, the uncertainty will be ~0.005 mag. The reason for the short-cadence is that V3890 Sgr is known to continually display variations of 0.02 mag on time scales of ten minutes (see Figure 57 of Schaefer 2010), plus fast time resolution is needed to pick up the white dwarf rotation.

V3890 Sgr has a 1.0-magnitude deep eclipse with a duration ~50 days. A primary eclipse will not occur during the *K2* Field 9 campaign. However, the *secondary* eclipse will occur during the last month of the Field 9 campaign. Such a secondary eclipse has never before been seen in any nova with a red giant companion.

V3890 Sgr had its previous eruption in 1990.3, so an inter-eruption interval of 27.9 years implies that the next eruption will be around 2018.2. An analysis of discovery statistics since 1890 had resulted in an estimated average recurrence time of 25 years, with a predicted next eruption in the year 2015 (Schaefer 2010). Our analysis of the stability of other RN inter-eruption times suggests that V3890 Sgr has ~20% variations, so the time of the next eruption is uncertain by around ±6 years. With this, there is a probability of ~3% that V3890 Sgr will erupt between now and the start of the Field 9 campaign. If so, then *Kepler* would get the first long-and-fast time series on a nova in eruption, and all with millimag 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, in the tail of their eruptions, with these being *guaranteed* cases of catching an ordinary nova late in their eruptions.] Also, there is ~3% 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 ~6% chance that K2 will catch V3890 Sgr during eruption, with uniquely wonderful coverage, and a good possibility of seeing new and mysterious phenomena.*

V3890 Sgr is one of the poorest studied of all ten known Milky Way RNe, with all extant photometry tabulated in Schaefer (2010). Even so, we know that the *K2* light curve will display a wide array of phenomena: **(1)** In June and July 2016, there will be a secondary eclipse. **(2)** Throughout, we will see the ordinary ellipsoidal modulation caused by a slightly out-of-round companion star rotating in view. **(3)** V3890 Sgr has poorly-seen currently-unexplained variations at the 0.1 mag level on daily time scales. **(4)** The RN shows the usual fast flickering on time scales of ten minutes, with this being somehow caused by instabilities in the inner disk. **(5)** The red giant companion has pulsations of amplitude near 0.1 mag on a 103.8 day periodicity. **(6)** The rotation of the white dwarf might reveal itself as a photometric periodicity, if the white dwarf has a high magnetic field. Further, on the ~6% chance of catching part of the soon-upcoming eruption, *K2 might* uniquely catch a variety of phenomena: **(7)** A pre-eruption rise could show some 'simmering' or failed-ignition of the nova. **(8)** The rise over the first minutes and hours of the nova event would provide a unique view how the ignition spreads around the white dwarf, with the white dwarf rotation bringing the burning region in and out of view as it spreads.

To support the *K2* time series, we will be taking BVRIJHK measures with the SMARTS 1.3-m telescope, plus spectra with the CTIO 1.5-m telescope. Prior examples of this on-going work appear in Walter et al. (2012).

Few RN 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. V3890 Sgr should be studied in its own right as a rare and interesting system. V3890 Sgr must also be studied as an exemplar of a prominent and important candidate solution for the uber-important SNIa progenitor problem.

Pagnotta, A., Schaefer, B. E., Clem, J. et al. 2015, 811, 32.

Schaefer, B. E. 2009, ApJ, 697, 721.

Schaefer, B. E. 2010, ApJSupp, 187, 275.

Schaefer, B. E., Landolt, A., Linnolt, M. et al. 2013, ApJ, 733, 55.

Schaefer, B. E., Pagnotta, A., LaCluyze, A. et al. 2011, ApJ, 742, 113.

Strope, R., Schaefer, B. E., & Henden, A. A. 2010, AJ, 140, 34.

Walter, F. M., Battisit, A., Towers, S. et al. 2012, PASP, 920, 1057; with full data and frequent updates at http://www.astro.sunysb.edu/fwalter/SMARTS/NovaAtlas/