K2 short-cadence characterization of the unusually slow nova V5558 Sgr

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We propose to obtain the first short-cadence K2 observations a classical nova: V5558 Sgr erupted in 2007 and is a very rare example of a thermonuclear runaway on a low-mass white dwarf. The K2 observations will be used to determine its orbital period, to constrain the binary parameter, and to probe the re-start of mass transfer following the nova eruption.

Cataclysmic variables (CVs) are short-period ($P_{\rm orb} \simeq 80$ min to a day) binaries in which a white dwarf accretes from a Roche-lobe filling (quasi) main-sequence companion. *Kepler* has observed various known CVs (e.g. Ramsay et al. 2012) and discovered many new ones (e.g. Fontaine et al. 2011; Barclay et al. 2012; Gies et al. 2013). Short cadence light curves have been used to improve our understanding of the thermal instability of accretion discs (Cannizzo et al. 2012; Kato & Osaki 2013) and of stochastic processes in accretion flows (e.g. Scaringi et al. 2012; Van de Sande et al. 2015). However, one very important phenomenon related to accretion onto white dwarf has so far not benefitted from *Kepler*'s untinterrupted high-precision time-series photometry: classical novae – because these rare events are heavily concentrated towards the galactic plane. The purpose of this *K2* DDT proposal is to rectify this situation by obtaining short-cadence observations of Nova Sgr 2007, also known as V5558 Sgr, which falls on silicon in Campaign 9.

Classical novae are thermonuclear run-aways on the surface of white dwarfs accreting hydrogen-rich material. The primary factor determining the ignition mass is the white dwarf mass, secondary parameters are the accretion rate and the white dwarf core temperature. The more massive the white dwarf, the lower the ignition mass: from $\sim 10^{-7} M_{\odot}$ for a $1.4 M_{\odot}$ Chandrasekhar-mass white dwarf to $\sim 5 \times 10^{-4} M_{\odot}$ for a low-mass $0.4 M_{\odot}$ He-core white dwarf (Townsley & Bildsten 2004). The immediate consequence of this dependency is that the *observed* sample of classical novae is strongly biased towards high-mass white dwarfs, and not representative of the underlying population of CVs. Yet, classical nova eruptions very likely have profound importance for the evolution of CVs, *in particular* for those with low-mass white dwarfs. CV Population syntheses predict a large number of systems containing low-mass white dwarfs (Politano 1996; Howell et al. 2001), yet not a single such system has been identified so far (Zorotovic et al. 2011), representing a major problem in our understanding of compact binary evolution. In a recent study, Schreiber et al. (2016) demonstrated that the large amount of mass ejected by from a nova eruption on a low-mass white dwarf is likely to result in an increase of orbital angular momentum

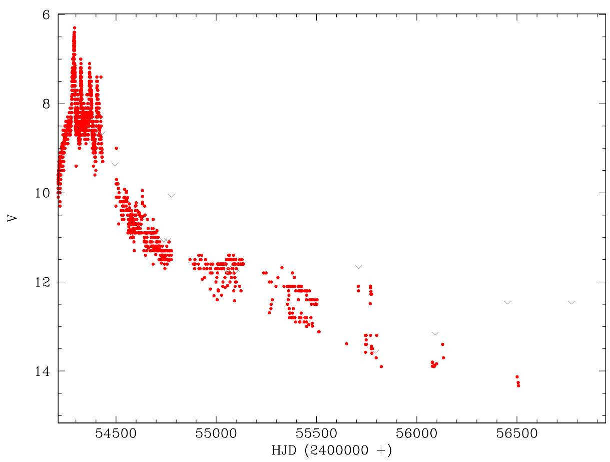

Figure 1. AAVSO light curve of V5558 Sgr, illustrating (a) the unusually slow evolution of the nova eruption, lasting $\simeq 60$ d, and (b) multiple re-brightenings. This slow evolution implies a low white dwarf mass, $\simeq 0.5 M_{\odot}$ (Hachisu & Kato 2015), though even lower masses cannot be excluded (Shen et al. 2009). Extrapolating the slowly declining light curve to the time of Campaign 9 suggests that *K2* will see the star at $V \simeq 16$.

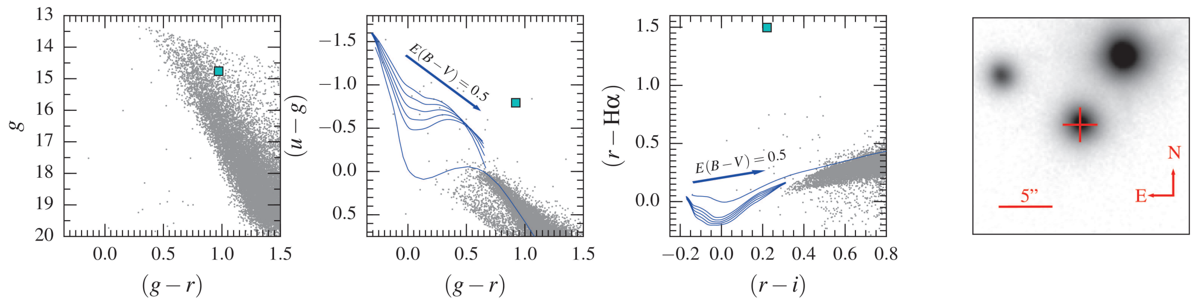

Figure 2. Left to right: $g, g-r$ magnitude-colour diagram, $u-g, g-r$ colour-colour diagram, $r-H\alpha$ color-colour diagram, and 20” postage stamp of V5558 Sgr, all obtained from VPHAS+ photometry. White dwarf cooling tracks and the location of the main-sequence are overlaid in blue. The relatively blue in $u-g, g-r$ of this young post-nova, combined with the very high extinction along this sight line ($E(B-V) \simeq 13$), suggests that the system is at a relatively short distance of at most 1 kpc. The very large $r-H\alpha$ clearly shows that the system has a very strong Hα emission line, as expected from the nova shell. Given the 4” pixel size of *K2*, short-cadence data for V5558 Sgr will not suffer from significant blending issues.

loss, which will increase the mass transfer rate — eventually causing the binary to merge, destroying the system. This approach offers a solution of the white dwarf mass problem but direct observational evidence for the hypothesis put forward by Schreiber et al. (2016) is missing.

We have identified one classical nova that falls in silicon in Campaign 9: V5558 Sgr. This nova was disovered on April 14, 2007, at $V = 10.3$, and kept rising for another ~ 150 d, before reaching its maximum brightness, $V = 8.4$, and then slowly fading. Super-imposed on the flat maximum were four $\simeq 1.5$ brightenings lasting 10–20 d (Fig. 1). Our VPHAS+ photometry (Fig. 2) unambiguously identifies the object as an Hα emission source, and shows that it is not suffering from blending. V5558 Sgr is among the slowest novae ever observed, implying a low mass white dwarf, $\simeq 0.5M_{\odot}$, (Hachisu & Kato 2015), consistent with the large ejecta mass of $(6.0 \pm 0.5) \times 10^{-4} M_{\odot}$ (Das et al. 2015), though even lower masses are possible (Shen et al. 2009). We propose to obtain *K2* short-cadence observations of V5558 Sgr during Campaign 9, from which we will determine the orbital period, estimate the binary inclincation, and explore for the first time how mass transfer re-establishes following a nova eruption. Such high-cadence long-baseline observations of a post-nova are entirely *terra incognita*, and may provide insight into unprecedented phenomena. We will complement the *K2* data with ground-based radial velocities to obtain dynamical mass measurements, and finally the forthcoming *Gaia* parallax of the system will turn its apparent magnitude into a luminosity and an accretion rate. Comparing the predicted and measured white dwarf mass will allow us to test nova theories and the measured accretion rate may provide first direct observational evidence for an impact of nova eruptions on CV evolution.

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