SEDM Proposal: A Complete Spectroscopic Sample of Bright TDEs and CLAGNs

Part I: Summary (1 paragraph)

We propose to continue our highly successful program of SEDM classification of tidal disruption events (TDEs) among blue, slowly rising, bright nuclear transients in the ZTF alert stream. We are also augmenting our program to include SEDM follow-up dedicated to discovering changing-look AGN (CLAGN). In the first 9 months of ZTF, we discovered 10 CLAGN from spectroscopic follow up of nuclear transients from previously identified narrow-line AGN, including the discovery of a new class of changing-look LINERs.

Part II: Team Members / Resources

PI / Point of Contact: Suvi Gezari (UMD/JSI)
Co-Is: Sjoert van Velzen (UMD/NYU), Brad Cenko (NASA Goddard/JSI), Tiara Hung (UCSC), Nadia Blagorodnova (Radboud), Matthew Graham (CIT), Shri Kulkarni (CIT), Lin Yan (CIT)

Science Working Group: ZTFbh
Associated Resources (facilities, etc.):

Discovery Channel Telescope (PI: Gezari; Accepted)
6 nights on DeVeny spectrograph in 2019A to follow-up ZTF nuclear transients
VLA (PI van Velzen; Accepted)
5 FAST triggers for newly discovered TDEs to look for radio emission. If radio emission is detected in the FAST trigger, we will trigger 5 multi-frequency SED observations.
XMM (PI Gezari; Accepted)
We will observe 6 TDEs that are discovered pre-peak in the X-rays. Take an initial observation within a week of discovery , plus one more epoch 5 months later.
Spitzer DDT (PI Yan; Accepted)
We will obtain high cadence mid-IR light curves for 7 TDEs (5 epochs each) that have redshift < 0.2 and the discovery phases no later than 20 days post-maximum light.
Swift (PI Gezari; Pending)
Key Project to observe 20 rising ZTF TDEs with magnitudes accessible by SEDM over the next 2 years with a cadence of 3 days.

Part III: Science Objectives (1 page)

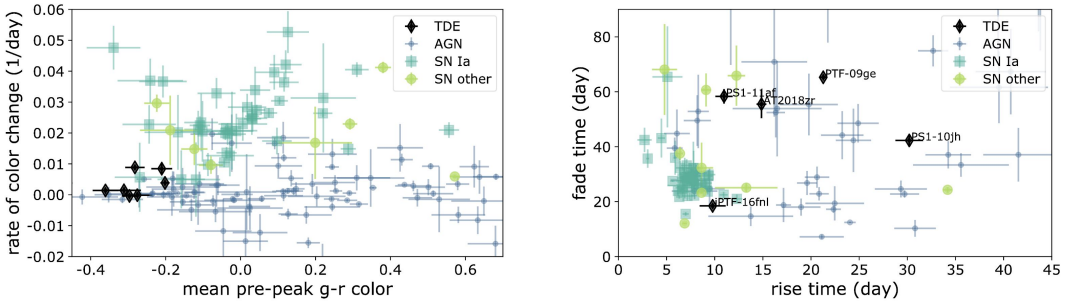
The multi-band (g,r) 3-day cadence and wide FOV of the ZTF camera will allow the assembly of the first statistical sample (32 per year through the MSIP survey) of TDEs from one single survey. Our goal is to use the SED machine (SEDm) to make timely identification of bright TDEs

(<19.5 mag) discovered by ZTF in order to trigger detailed follow-up observations to study the physical mechanisms operating in TDEs.

As shown by recent theoretical work, the two fundamental parameters of a black hole — mass and spin — are imprinted on the light-curves of TDEs. However, observations of optical TDEs in the past decade have shown inconsistent results from the classical prediction for emission from a newly formed accretion disk. The temperature of optically discovered TDEs is too cold (a few x 10^4 K rather than the expected few x 10^5 K), implying an optical emitting region that is orders of magnitude larger in size (10^{14} cm vs 10^{12} cm) than expected for a stellar debris disk.

These discrepancies have motivated a number of second generation models with increased sophistication. Some works argue that a gaseous envelope could reprocess the X-ray photons produced by the accretion disk and re-emit in the UV and optical. Alternatively, the optical emission may originate from energy dissipated in stream-stream collision shocks caused by relativistic apsidal precession. **We are conducting a comprehensive panchromatic imaging and spectroscopic follow-up program from the radio to the X-rays designed to shed light on the emission mechanism operating in optically bright TDEs.**

The SEDM, given its flexibility in scheduling, serves to optimize the usage of these follow-up programs by making prompt classification of the TDE candidates. The brightness limit (19.5 mag) of the SEDM also ensures the classified TDEs are bright enough for high S/N observations with ground and space-based telescopes. From our systematic analysis of nuclear transients in the first 9 months of the ZTF survey, we have formalized an efficient TDE selection strategy (e.g. cuts on the spatial separation, transient color, AGN catalog matches, variability amplitude, and rise time to peak). Our cuts (see Figures below from van Velzen et al. 2018) efficiently filter out common AGN and SNe, and yield a manageable number of remaining TDE candidates for a complete spectroscopic classification of bright TDEs in ZTF.



Changing-look AGN (CLAGN) are an exciting new class of extreme AGN which completely change their spectroscopic class from a narrow-line AGN (most often a Seyfert 1.8/1.9/2 galaxy) to a broad line AGN (most often a Seyfert 1) or vice versa.

iPTF discovered the first case of a LINER transforming into a broad-line quasar. With ZTF, we have now discovered 4 more of this type, indicating a new class of "changing-look" LINERs. We have found that SEDM is an excellent tool for discovering the emergence of broad lines. From a study of SEDM spectra taken of AGN of various spectral types, we have determined that either a blue continuum increase or a FWHM(Halpha +[N II]) > 125 A, can distinguish broad from narrow-line AGN observed with the SEDM.

Part IV: Past Usage (1 page)

Description: We have had terrific success classifying TDEs and CLAGN with the SEDM. These include:

3 TDEs:

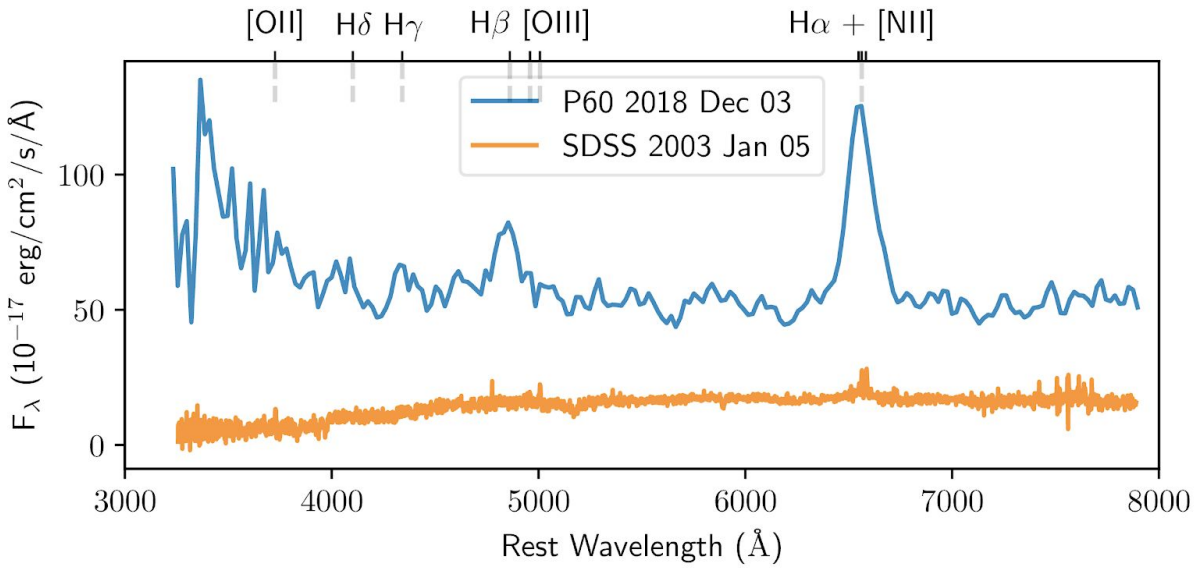
-- NedStark (ZTF18aabtxvd) at z = 0.075, rpeak = 17.6 mag

-- JonSnow (ZTF18aahqkbt) at z = 0.051, rpeak = 18.0 mag

-- SansaStark (ZTF18abxftqm) at z = 0.088, rpeak = 18.2 mag

and

10 CLAGN, including the discovery of a new class of "LINER" CLAGN (Frederick et al., in prep.), which demonstrate a dramatic transformation into a broad-line AGN from a weak narrow-line LINER archival SDSS spectrum. See figure below of SEDM spectrum of ZTFaasszwr as an example.



Publication List:

-- van Velzen et al. 2018, “The first tidal disruption flare in ZTF: from photometric selection to multiwavelength characterization”, ApJ, submitted (arXiv:1809.02608)
-- Hung et al., in prep., “Discovery of High Velocity Broad Balmer Absorption Lines in a Tidal Disruption Event”
-- Frederick et al., in prep., “A New Class of Changing-Look LINERs”
-- ATel #12263, “Classification of AT2018hco (ATLAS18way/ZTF18abxftqm) as a tidal disruption flare”, van Velzen et al.
-- ATel #12053, “ZTF Discovery of a Tidal Disruption Event at z=0.051”, Gezari et al.

Part V: Observing Details (1 page)

Triggering Criteria:
Following our experience vetting nuclear transients in the first 9 months of the survey (see van Velzen et al. 2018), we will trigger SEDm on transients that satisfy the following criteria

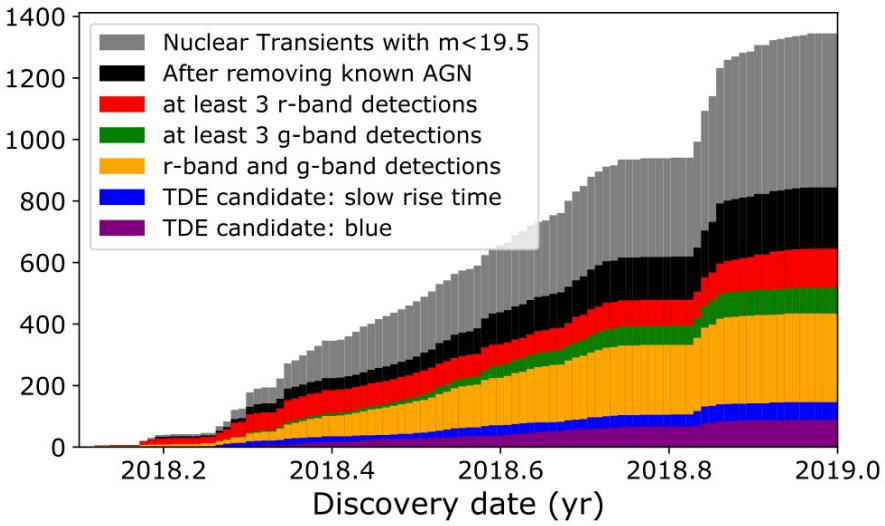
1. g or r < 19.5 mag
2. The transient is spatially coincident with an extended galaxy.
3. Separation from the host centroid is less than 0.5”.
4. The transient has not been reported as an AGN.
5. The position of the transient has no variability history in PTF, PS1, or CRTS.
6. The amplitude of variability (Δm) is greater than 0.5 mag.
7. The transient has a g-r < -0.1 mag
8. The rise time > 10 days

From our systematic filtering via the GROWTH Marshal and AMPEL, including applying an extra star/galaxy classification cut using Gaia and PS1, auto-saving to the Marshal, automatic AGN catalog matching, automated photometric characterization (rise time, mean color, color evolution, fade time), and daily ranking of TDE candidates for spectroscopic classification for SEDM, DCT, Keck, and P200, we know with good accuracy (details below) that the criteria above yield a **trigger rate of 0.5/week**.

Below we plot the cumulative distribution of bright (m < 19.5 mag) nuclear transients as a function of time since the start of the survey, which not including weather losses and downtime due to engineering, corresponds to an effective time of 37 weeks of ZTF survey operations. We also show subsets of nuclear transients, including those that satisfy our SEDM trigger criteria (not-AGN, blue and slow-rising), which were detected at an average rate of:
nuclear transient, m < 19.5 mag, not AGN, slow rising: 2.95/week
nuclear transient, m < 19.5 mag, not AGN, blue: 2.38/week

nuclear transient, m < 19.5 mag, not AGN, blue and slow rising: 0.32/week

In 2019, we expect these rates to **increase** due to the availability of g band references for most of the MSIP area, allowing for g-r color (a required measurement to be included in the “blue” category) to be determined for a larger fraction of transients. Thus we request a trigger rate of 0.5 per week.



Synergy with RCF: We would like to continue our mutually beneficial relationship with the RCF survey. We will continue to transfer any SEDM spectra that end up being SNe to RCF. Similarly, we request that any transients that RCF triggers SEDM on that end up being AGN or TDEs be transferred to our program for us to determine the final classification, and to post an ATel. **Given the landscape of overlapping surveys, and the public MSIP data stream, we plan to post ATels for all the bright TDEs classified by our SEDM program.**

Trigger Method:
GROWTH Marshal, Nuclear Transients program

Observing Sequence:
According to the exposure time recommendations in the call for proposals, we request an exposure time of 2250 sec + an overhead of 180 sec = **2430 sec total per target.**

Total Time Request:
TDE candidates: 0.5 triggers/week x 52 weeks x 2430 sec = **63 ksec**

CLAGN candidates: 1 per month x 2430 sec = **29 ksec**
TOTAL: 92 ksec

Part VI: Publication Plans (0.5 page)

-- Rate of TDEs in ZTF Years 1-2
-- Host Galaxy Properties of TDEs in ZTF Years 1-2
-- Multiwavelength properties of individual TDEs (several papers)
-- UV and optical spectroscopy TDE synthesis paper
-- Radio synthesis TDE paper
-- X-ray synthesis TDE paper
-- Infrared dust echo synthesis TDE paper
-- light curve synthesis TDE paper
-- CLAGN in ZTF Years 1-2 paper