Holding out for a Hero: X-ray, UV, and optical characterization of the nuclear transient **AT2020afhd**

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There is complex landscape of transients associated with galaxy nuclei and related to accretion onto SMBHs.

- AGN variability
- Changing Look AGN (CLAGN)
- Bowen Fluorescence Flares (BFFs)
- Tidal Disruption Events (TDEs)
- Ambiguous Nuclear Transients (ANTs)
- Extreme Nuclear Transients (ENTs)

Overlapping characteristics make it hard to:

- 1. Classify transients robustly
- 2. Understand the underlying mechanisms producing observed properties



Zero to "Hero" a.k.a. AT2020afhd / ZTF20abwtifz: a normal TDE?



Zero to "Hero" a.k.a. AT2020afhd / ZTF20abwtifz: a normal TDE?

- Classified as a TDE based on its blue optical colors, bright UV flux* with UVOT, optical spectral features, and lack of AGN-like variability/colors in WISE (AstroNote 2024-37)
 - given the ZTF BH SWG name **"Hero"**
- X-ray detected* with XRT
- **Radio detected** (PI: K. Alexander, see AstroNote 2024-56)
- Reclassified two weeks later as a Bowen
 Fluorescence Flare (Trakhtenbrot+19, see AstroNote 2024-53)





*Triggers include requests from: Hammerstein, Wang, Jiang, Huang

AT2020afhd / ZTF20abwtifz a.k.a. "Hero": a normal BFF?





- Bowen fluorescence line emission: O III λ 3133 and N III λ 4640 + He II λ 4686
- Little time evolution of continuum/line emission
- X-ray SED broadly consistent with unobscured AGN (Γ ~ 1.9 2.5)



AT2020afhd / ZTF20abwtifz a.k.a. "Hero": a normal _____

- Significant UV/optical evolution
- Variable X-ray light curve
- X-ray spectrum consistent with kT ~ 0.08 keV blackbody
- Additional optical spectra showed double-peaked line profiles, broad He II + NIII complex, emergence of some coronal lines





Additional optical spectra showed the emergence of double-peaked line profiles, broad Bowen fluorescence emission, and coronal lines.

Double-peaked emission lines seen in some TDEs

• Modeled with elliptical accretion disk

AGN are well-known to have double-peaked lines associated with accretion disks





Double-peaked emission lines in TDEs are often modeled by elliptical accretion disks.



After our Hero returned from behind the Sun...



After our Hero returned from behind the Sun...



- Loss of broad component in several lines •
- Relative strength of red/blue peaks has • flipped

After our Hero returned from behind the Sun...

flipped



Circular disk profile with rotation spiral arm feature (Schimoia+12)

Hβ

— · · · He II

4800

4900

5000

(Strateva+03)

Hero shows similarities to various classes of nuclear transients, including TDEs.



AT2020afhd / ZTF20abwtifz a.k.a. "Hero"

- Shows X-ray, optical, and UV emission characteristic of TDEs with significant evolution in the UV/optical light curve and optical spectra
- Similarities to multiple other classes of nuclear transients, including BFFs or TDEs in AGN
- Evidence for presence of preexisting accretion disk, possibly illuminated by a TDE
- Post-transient observations may provide more information on the nature of this transient/host in "quiescence"









Lightcurve for 2020afhd Mar 2025 0.3-10 keV Counts / second 10^{-1} 10-2 60700 60400 60500 60600 Time (MJD)





Transients related to NLSy1

		?	×			\checkmark	×	×	×		
Name	$\log M_{\rm BH} < 8$	${\rm H}\beta{<}2000$	Fe II	$[\text{OIII}]/\text{H}\beta < 3$	$\Delta g - r$	UV	X -ray Γ	W1-W2	Re-	Spec. class	Interp.
	$[M_{\odot}]$	$\rm km~s^{-1}$		[flux ratio]	$\sim 0~{\rm mag}$			$>0.7 \text{ mag}^{\mathrm{a}}$	brighten		
AT2019brs	×	\checkmark	\checkmark	\checkmark	×	\checkmark	\checkmark^{b}	\checkmark	×	HeII+NIII	AGN
AT2019pev	\checkmark	\checkmark	×	\checkmark	\checkmark	\checkmark	3	×	\checkmark	HeII+NIII	AGN
AT2019fdr	\checkmark	\checkmark	\checkmark	\checkmark	×	\checkmark	×	×	×	FeII	TDE
AT2019avd	\checkmark	\checkmark	\checkmark	\checkmark	×	\checkmark	5	×	\checkmark	HeII+NIII	AGN
AT2020hle	\checkmark	\checkmark	×	\checkmark	\checkmark	\checkmark	\checkmark^{b}	×	×	HeII	TDE
CSS100217	\checkmark	\checkmark	\checkmark	\checkmark	×	\checkmark	3	\checkmark	×	FeII	AGN
PS16dtm	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark	$2^{\rm c}$	×	×	HeII+FeII	TDE
AT2017bgt	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark	2	×	\checkmark	HeII+NIII	AGN
AT2018dyk	\checkmark	\checkmark	×	\checkmark	×	\checkmark	3	×	×	HeII	AGN
PS1-10adi	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark	\checkmark	\sqrt{b}	×	×	FeII	TDE

Frederick+21