Examining infrared echoes of recent optical tidal disruption events with NOT and WISE

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Tidal disruption events and IR echoes

- Tidal disruption event, **TDE**, caused by star getting destroyed by supermassive black hole in the centre of a galaxy, energy ~10^{51} - 10^{52} erg
- UVO radiation can get absorbed and re-emitted in IR wavelengths by circumnuclear dust ⟹ **IR-echo**!
- Due to light-travel-time delay, light from heated distant dust arrives at later times and causes the echo to be long lived
- Needs to be separated from TDE reprocessing envelope emission

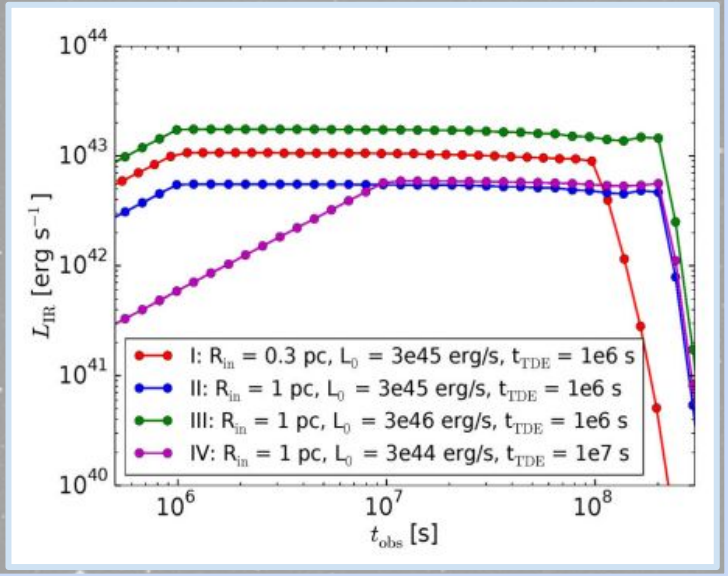

Figure: Wenbin Lu et al. 2016

Tidal disruption events and IR echoes

- Models and simulations urged researchers to look for these echoes
  - Objective to figure out dust properties and how many TDEs have strong echoes
- Previous systematic study found IR-echoes from 48% of TDEs from between 2019-2021 with low dust covering factors

target	ASASSN-18zj	ASASSN-15lh	ASASSN-15oi	ASASSN-14li	iPTF-16fnl	PTF-09ge	ASASSN-18pg	PS18kh
f_c (%)	0.79	1.48	0.14	0.66	0.30	1.51	0.37	1.10

Data from Ning Jiang et al. 2021

But how actually can we observe them in IR?

$$f_c = \frac{L_{dust,peak}}{L_{BB,peak}}$$

(NEO)WISE(R) mission and TDEs

- All sky survey in MIR (W1 3.4μm, W2 4.6μm)
- Publicly available full dataset makes possible to do photometry on all classified TDEs
- Deep unWISE coadds for template subtractions
- Total of 39 targets observed, 15 with clear IR-echo ⟹ 38,5%
- High dust covering factors from basic SED fittings

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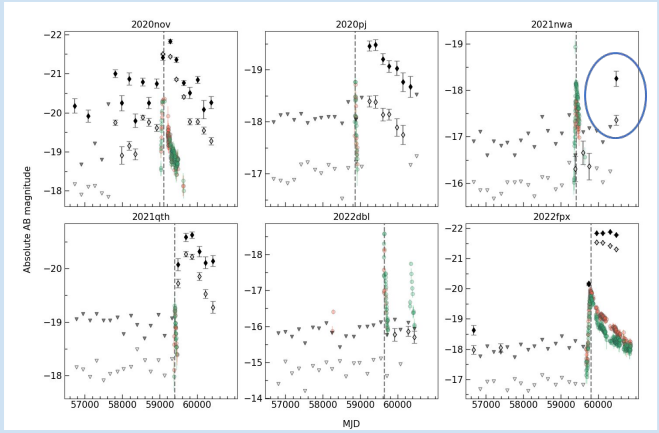

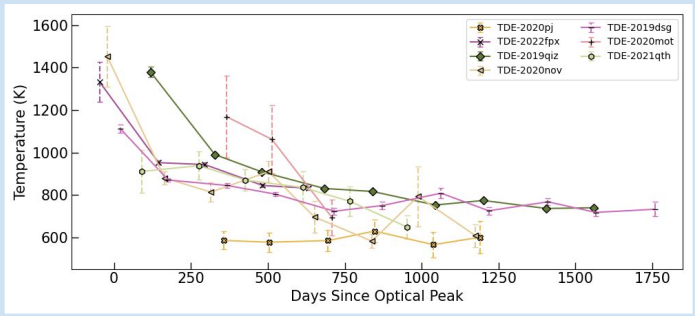

target	2019dsg	2019qiz	2020nov	2020pj	2021qth	2022fpx
f_c (%)	11.1	6.2	24.3	10.4	34.1	13.1

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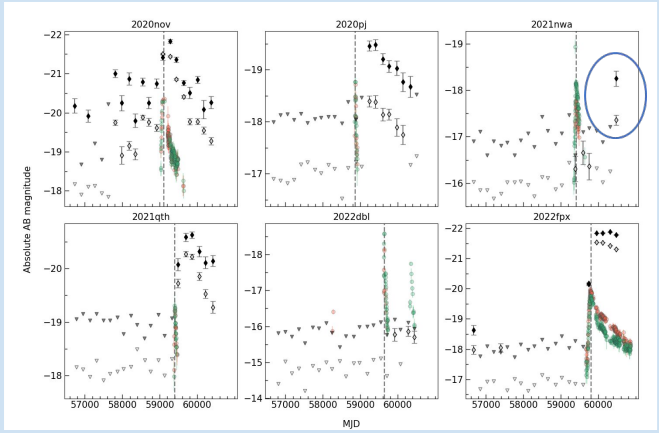
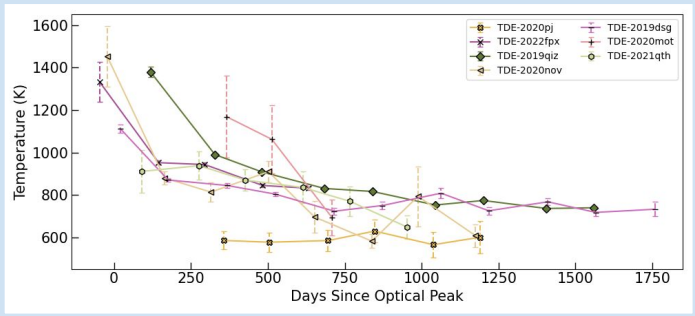
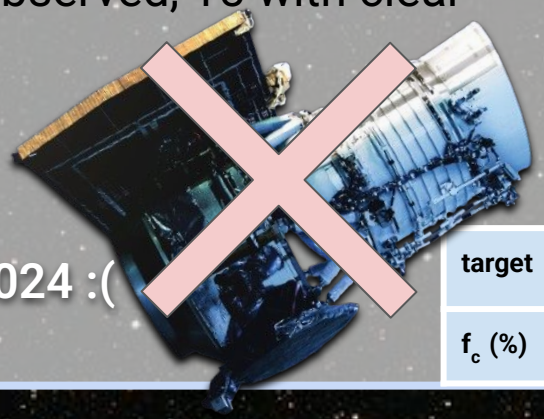




End of mission:

8th of August 2024 :(



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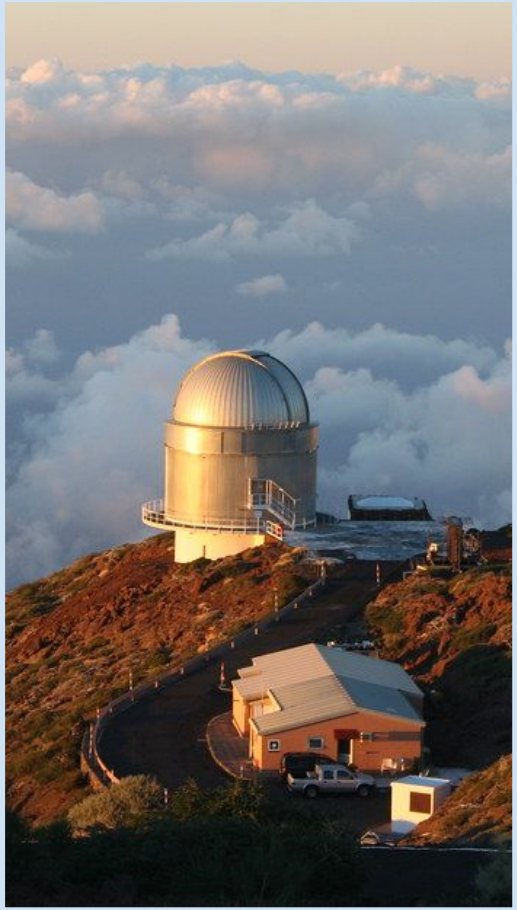
What now after NEOWISE mission?

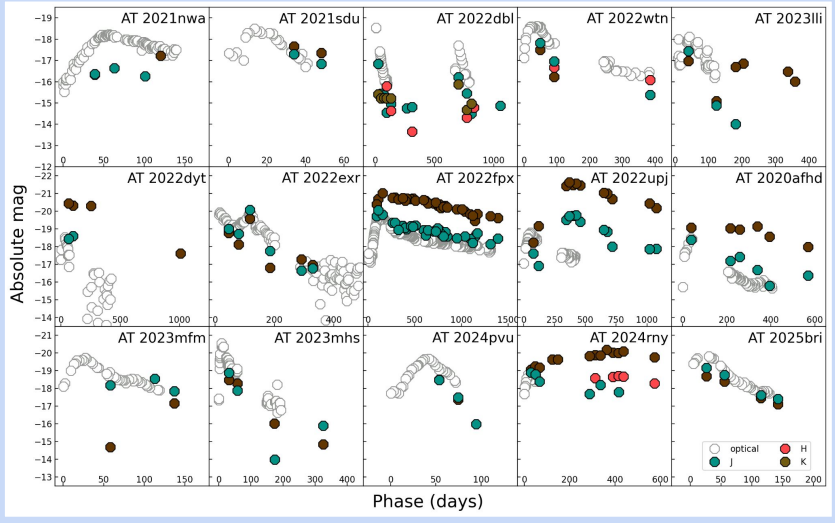
- Need for diverse IR observations of recent and upcoming TDEs ⟹ NOTcam of Nordic Optical Telescope!
  - NIR (Y), J, H, Ks, filters: (1.036), 1.250, 1.644 , 2.149 μm
  - Better restraints on SED fits on IR data
  - Statistical analysis on much larger set of IR detections from TDEs
- Have to wait for target TDE to fully fade before gathering template images
- Program has been ongoing from 2021



Sample and set of observed targets

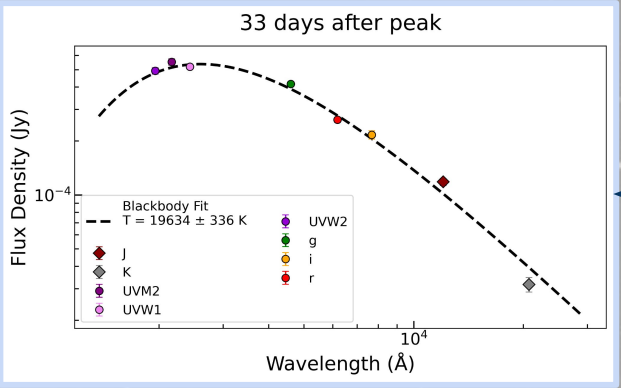
- Targets picked based on TNS TDE-classification and z < 0.1.
- Perform template subtracted PSF photometry on observed targets with **Autophot**[1] and **Hotpants**[2] to see if possible IR emission present
  - Follow up on any young ones that have it!
  - Take templates of old, faded ones
- preliminary sample: different behaviours
  - Multiple long lived echoes
  - Different J-K colours
  - Repeating TDE: AT2022dbl

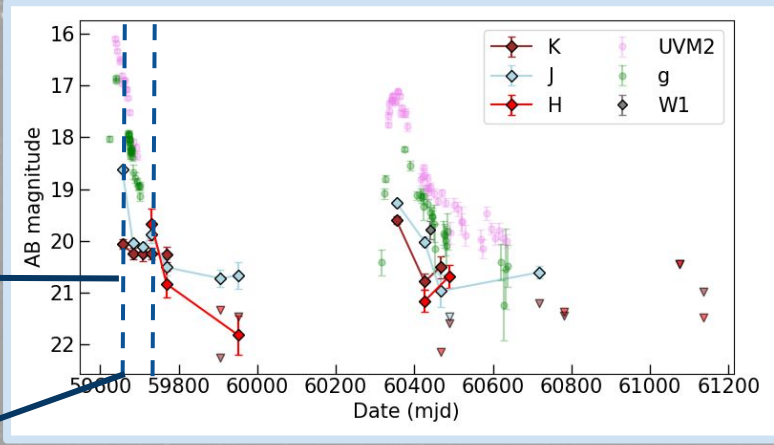
Tom's paper on AT2019azh:
https://ui.adsabs.harvard.edu/abs/2026A%26A...708A.139R/abstract



[1]S. J. Brennan and M. Fraser. The automated photometry of transients pipeline (autophot)
[2]Andy Becker. "the High Order Transform of PSF ANd Template Subtraction package (hotpants)"

SED fittings example: 2022dbl

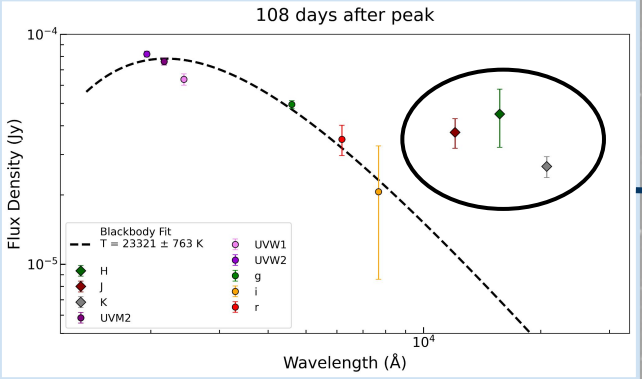




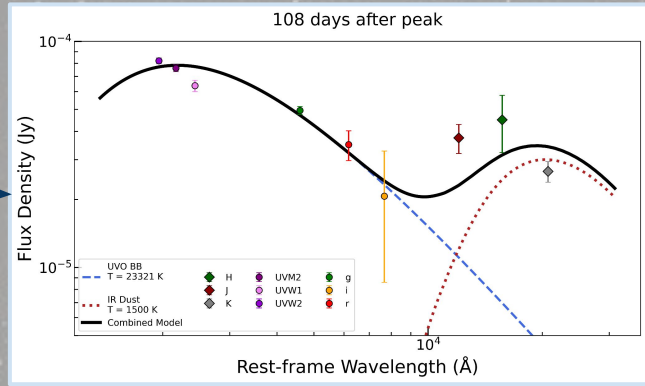
No visible IR excess…

… But at later times:

Try to find good dust composition for fit



IR flux much brighter than UVO bb fit predicts



Additional modified dust blackbody?

Results, summary and future

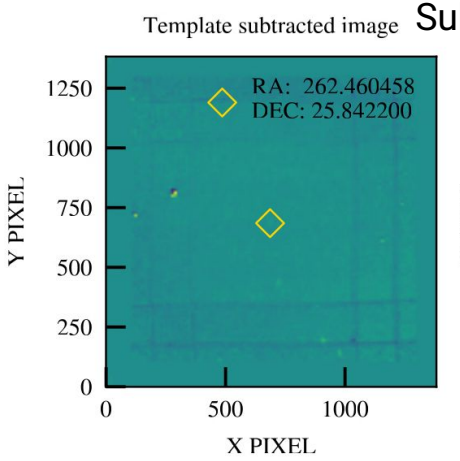
- Dust blackbodies could be used to portray IR excess found in the sample, but the fits aren't perfect
  - We are looking into possible different dust properties and power laws to see which describes observations the best
- We need continuous IR observations of TDEs to better understand the IR emission seen in the light curves!
  - At the moment our program is only one following newest TDEs in IR
- In the future our study can complement with SPHEREx, ROMAN, JWST observations

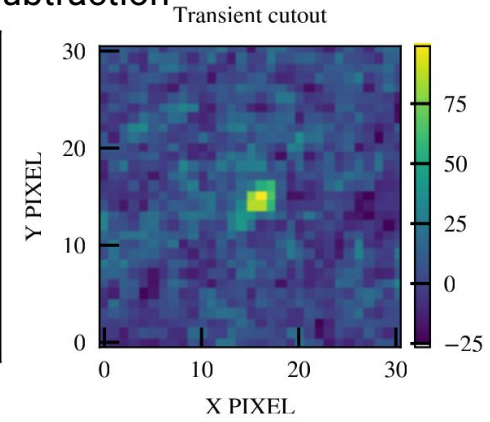
Thank you!

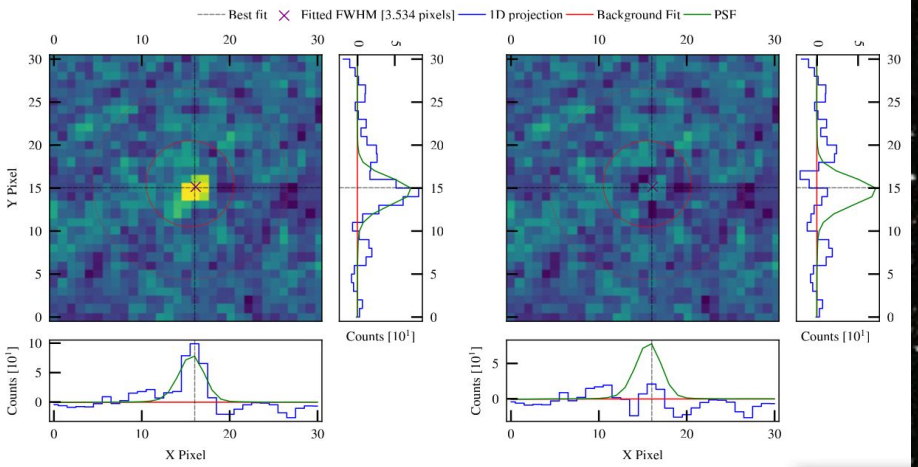
Additional figures: autophot and hotpants

PSF photometry

Subtraction







Limiting magnitude:
Injection fake sources