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

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Background and context

Tidal disruption events (**TDE**s) occur when a star is disrupted by a supermassive black hole, causing luminous flares that are observable across the electromagnetic spectrum. While most emission is detected in the optical/UV, an increasing number of TDEs show delayed infrared emission, known as **infrared echoes,** produced by circumnuclear dust reprocessing optical/UV radiation into IR. These provide a unique probe of the circumnuclear environment revealing the dust distribution in quiescent galaxies.

Previously WISE (and its NEOWISE reactivation) has taken MIR images of multiple TDEs before its decommissioning in 2024. We are conducting an IR survey to gather comprehensive set of observations of TDEs with the Nordic Optical Telescope's NOTcam instrument in the NIR regime to complement the NEOWISE survey. By observing the peak of TDE at these shorter wavelengths than WISE, we have detailed window to the hottest dust and explore otherwise forgotten observational regime of early time NIR of TDEs.

Survey summary and methods

- Sample of optically selected TDEs with z < 0.1.
- Trigger follow up NIR obs with NOTcam.
- After fading, get templates of the host galaxy.
- PSF photometry with *autophot* (Brennen, S. et al 2022) on images template subtracted with *Hotpants* (Becker, A 2015).
- Combine with NEOWISE observations, with photometry from template subtraction using unWISE coadds.
- Gather UVO data using *manyTDE* (Mummery,A, van Velzen,S et al 2023) .
- Analyse collected SED with different types of modified bb fittings to search for IR excess.

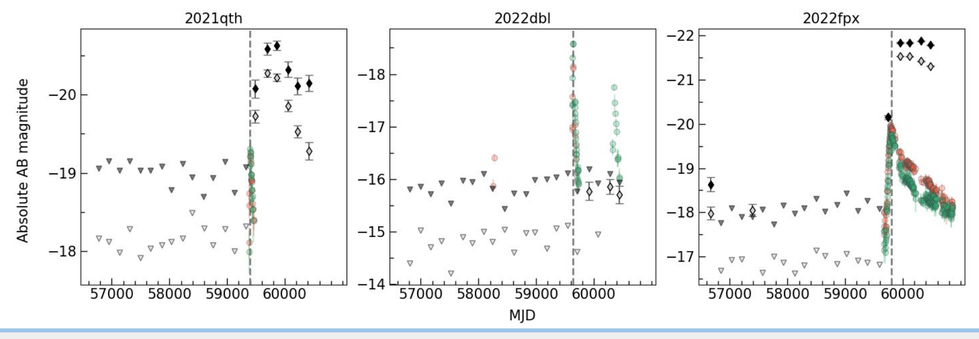

Figure 1: Example light curves from previous summer project that focused on looking into MIR detections to find dust echoes, with WISE bands marked as dark gray for W1 and light gray for W2. AT2022dbl is brighter in NIR when compared to MIR.

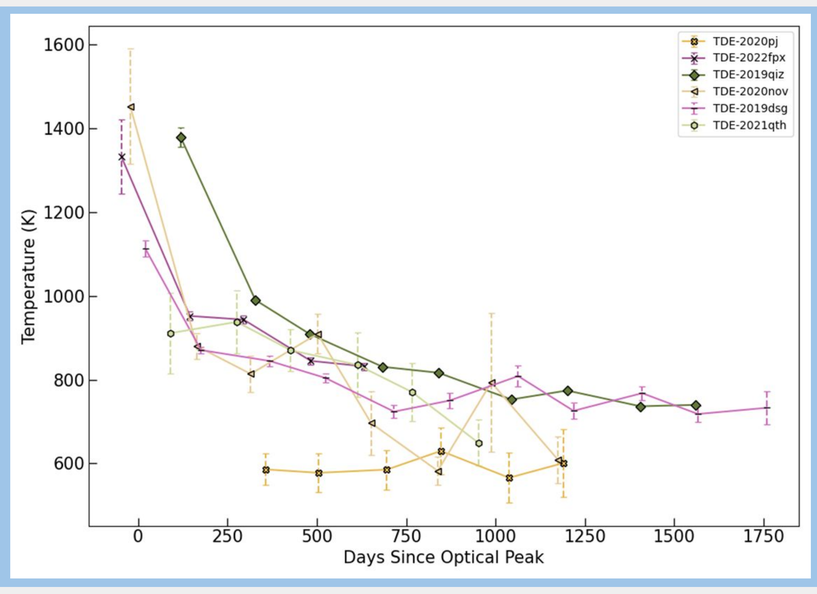

Figure 2: Temperature development of multiple TDE targets derived from SED fits to only NEOWISE data, showing how different TDEs can be in our sample. It clearly shows how 2020pj is much cooler than the trend of other TDEs.

Example: AT2022dbl

As an example we present one of our multiple targets, AT 2022dbl. We have obtained extensive IR dataset for both peaks of this repeating TDE. The K filter has considerably slower decline after the first peak compared to second burst.

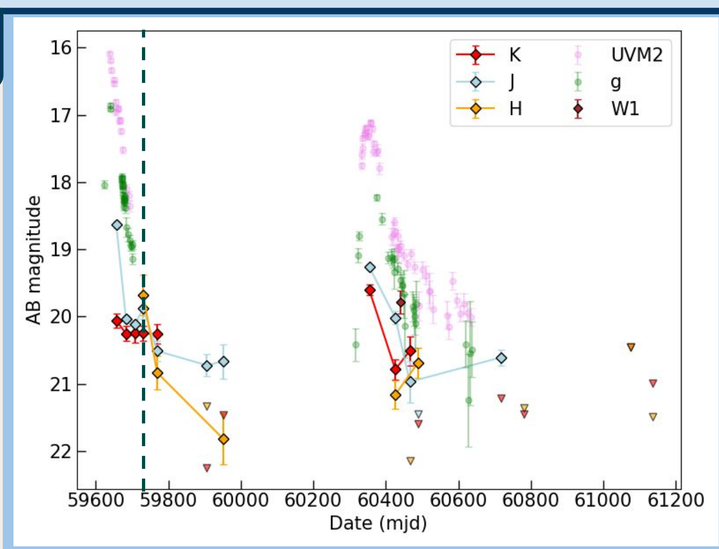

Figure 3: All observation epochs plotted with two of used UVO filters.

SED fit epoch in Figure 4 shown with dashed line.

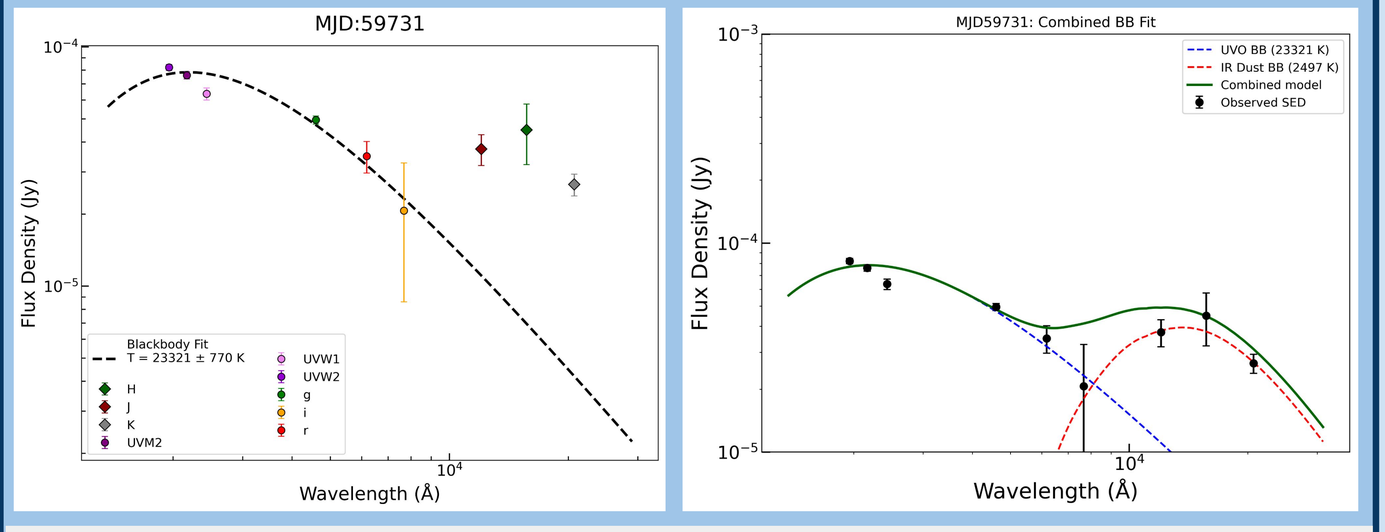

Figure 4: Left: Optical blackbody fit to 2022dbl SED's UVO data points for epoch 59731MJD with clear IR excess. Left: Additional second modified blackbody of Milky Way dust fitted to same SED. The two combined black bodies show that there is possible IR echo after the first flare.

Diverse echo sample

Our preliminary photometry of observed TDEs reveals noticeable diversity in IR behaviour.

In addition to repeating property of 22dbl, we have detected long-lived IR echoes seen in the middle row and targets with noticeable (J-K) color differences. Some of them exhibit redder color (2021sdu), while some are more blue (2025bri).

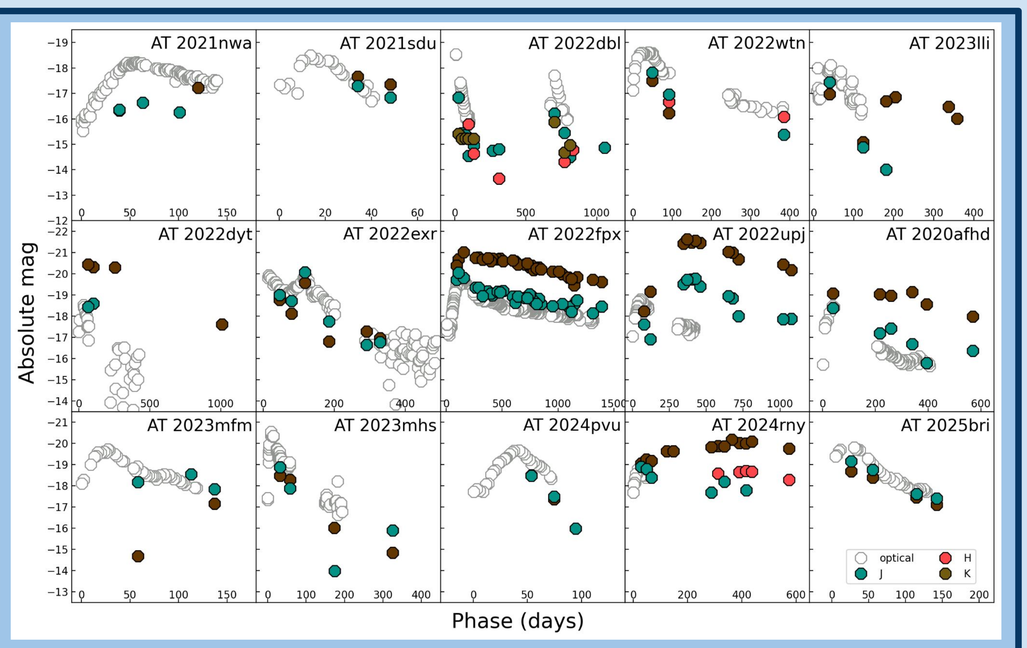

Figure 5: Set of NIR photometry of the TDE sample shown with optical data.

Conclusions and future

Our survey is now crucial for discovering and analysing IR echoes from future TDEs, as the IR field doesn't have constant ongoing survey comparable to WISE. Being able to to respond to newly optically detected TDEs with prompt IR observations is important due to their relatively short durations. Additionally the data on dust behaviour and composition will give us spectacular chance to understand TDEs IR echoes.

In the future, our data will complement observations with SPHEREx, Roman, and JWST.

Acknowledgements

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References

- S. J. Brennan and M. Fraser. The automated photometry of transients pipeline (autophot)
- Andy Becker. "the High Order Transform of PSF ANd Template Subtraction package (hotpants)"
- Mummery et al., 'Fundamental Scaling Relationships Revealed in the Optical Light Curves of Tidal Disruption Events'

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