The tidal disruption event AT2017eqx: spectroscopic evolution from hydrogen rich to poor, through an atmosphere and outflow

Nicholl et al. 2019, MNRAS 488, 1878

AT2017eqx was discovered by the PanSTARRS and ATLAS surveys. We classified it spectroscopically as a TDE in a post-starburst galaxy using the MMT and Magellan telescopes.

Photometry from Swift, FLWO and Swope show a typical $L \approx 10^{44}$ erg/s and constant $T \approx 25000$ K.

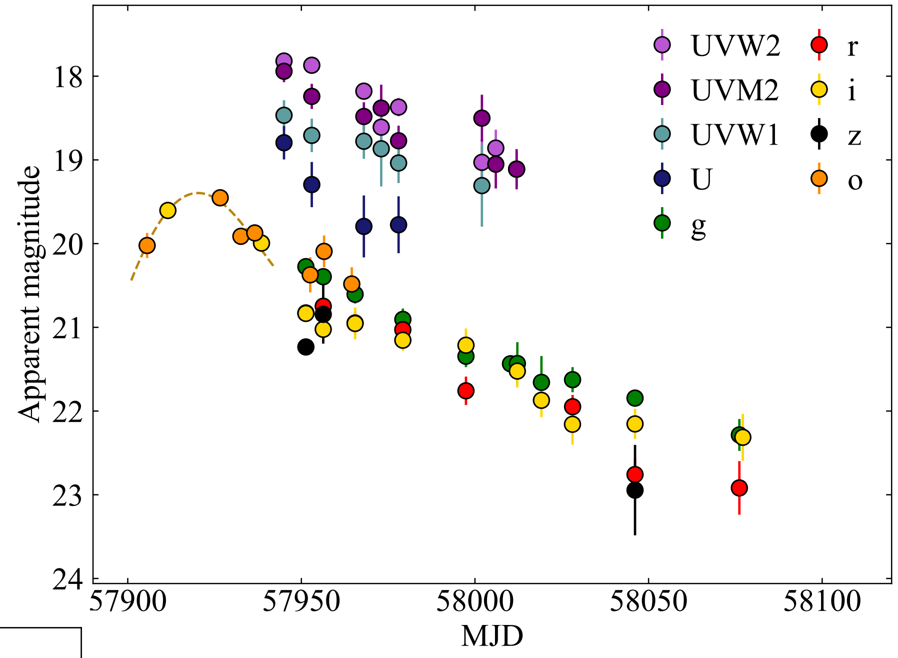
The early spectra show broad lines of H I and He II 4686.

After a few months, He II / Hα ratio changes from ≈2 to >10, with H lines no longer detectable.

Simultaneously, He II becomes blueshifted by 5000-8000 km/s.

The late-time spectrum resembles He-strong TDEs such as PS1-10jh, PTF09ge and ASASSN-15oi.

This proves that a H-poor spectrum does not indicate the disruption of a stripped star. Instead, the He II / H ratio must be a sensitive function of physical conditions.



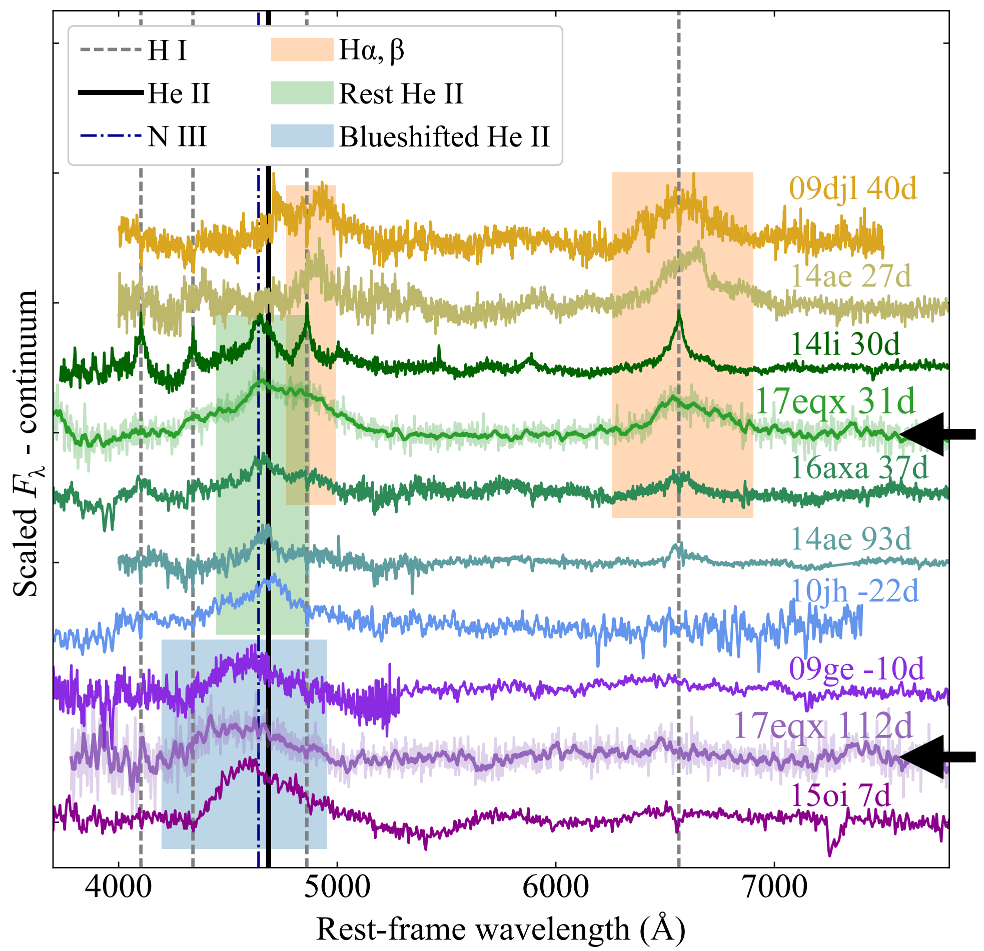
The evolving He II / Hα ratio can be explained by changes in the physical size of the emitting region For a more compact configuration, Hα is optically thick throughout (Roth et al 2016).

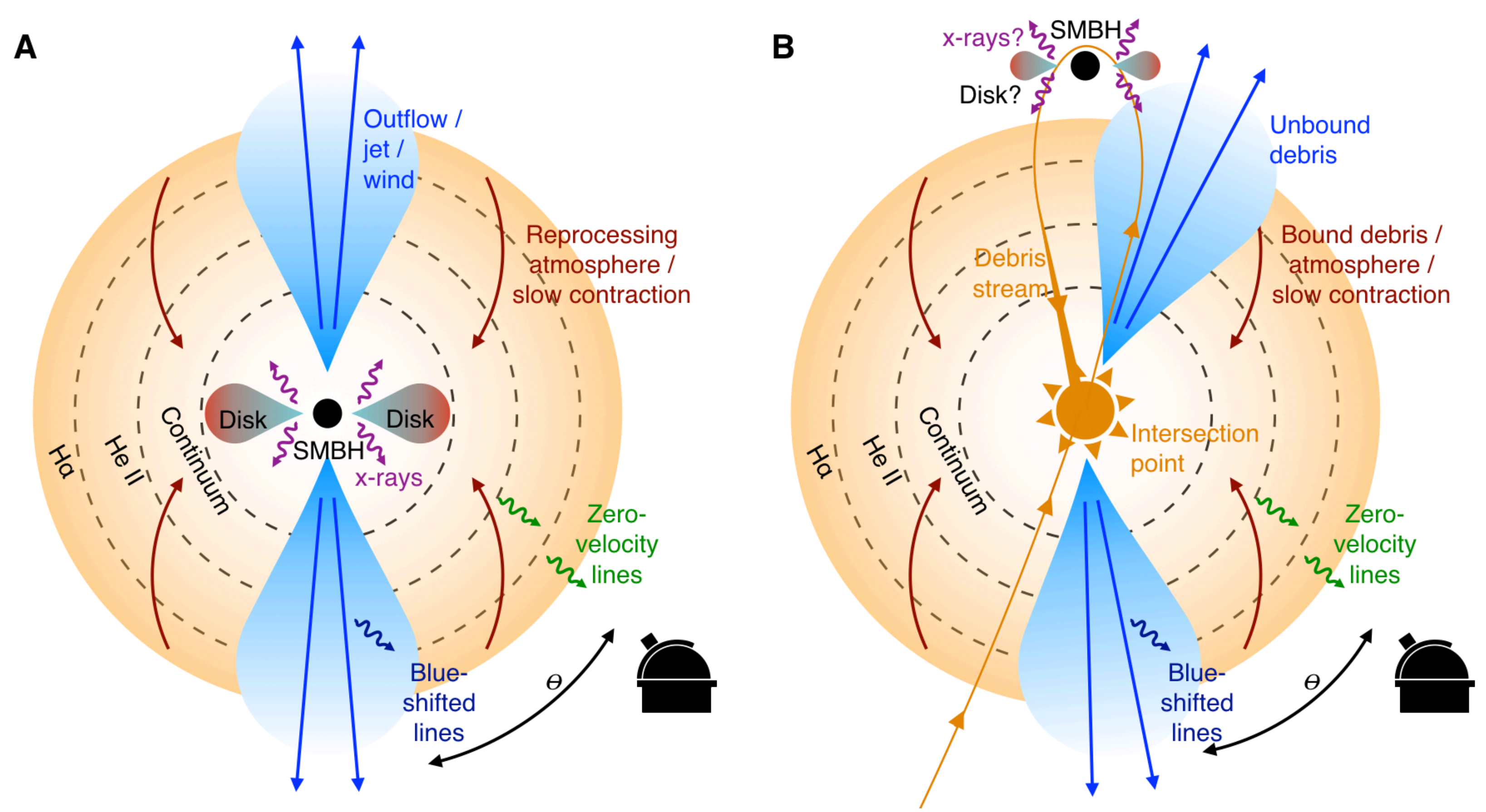
Contraction of a thermally-emitting envelope is also consistent with the decline in luminosity at constant colour temperature.

However, the blueshifted He II line indicates outflowing material: the geometry of the TDE debris must include both inflowing and outflowing regions.

This is shown in the schematic below: a quasi-spherical envelope undergoing slow contraction under gravity, and an outflow confined to a narrow angular range. This applies regardless of underlying power souce (accretion, A, vs circularisation, B).

Implication: our viewing angle towards TDEs determines when, if ever, the blueshifted lines are revealed.





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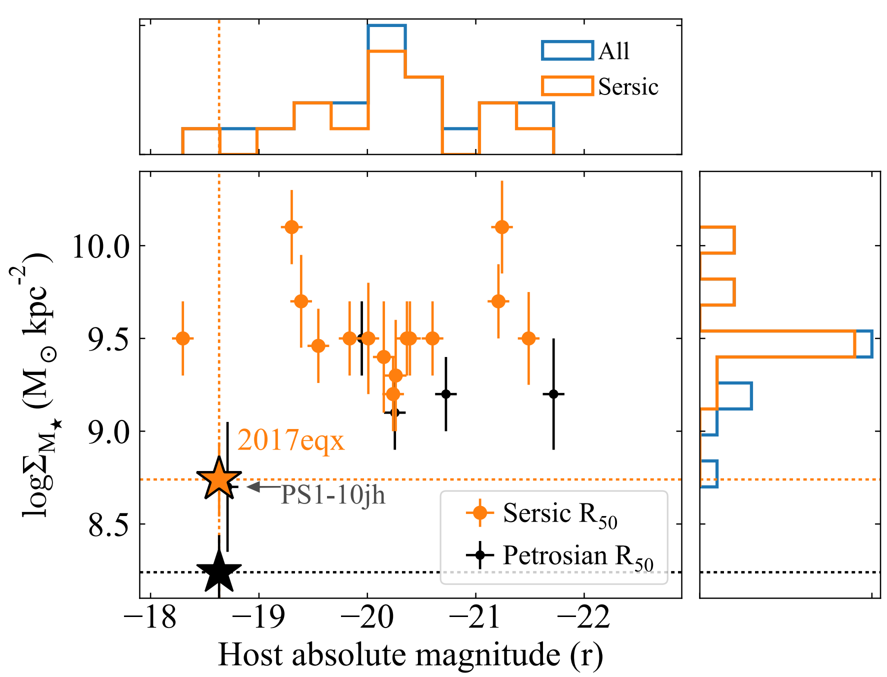
We modelled the light curve using the TDE model in the MOSFiT package (Guillochon et al 2018, Mockler et al 2019). The model assumes a fallback rate dM/dt (M_h, M_*) derived from simulations, with a simple prescription for viscous delays and a blackbody SED.

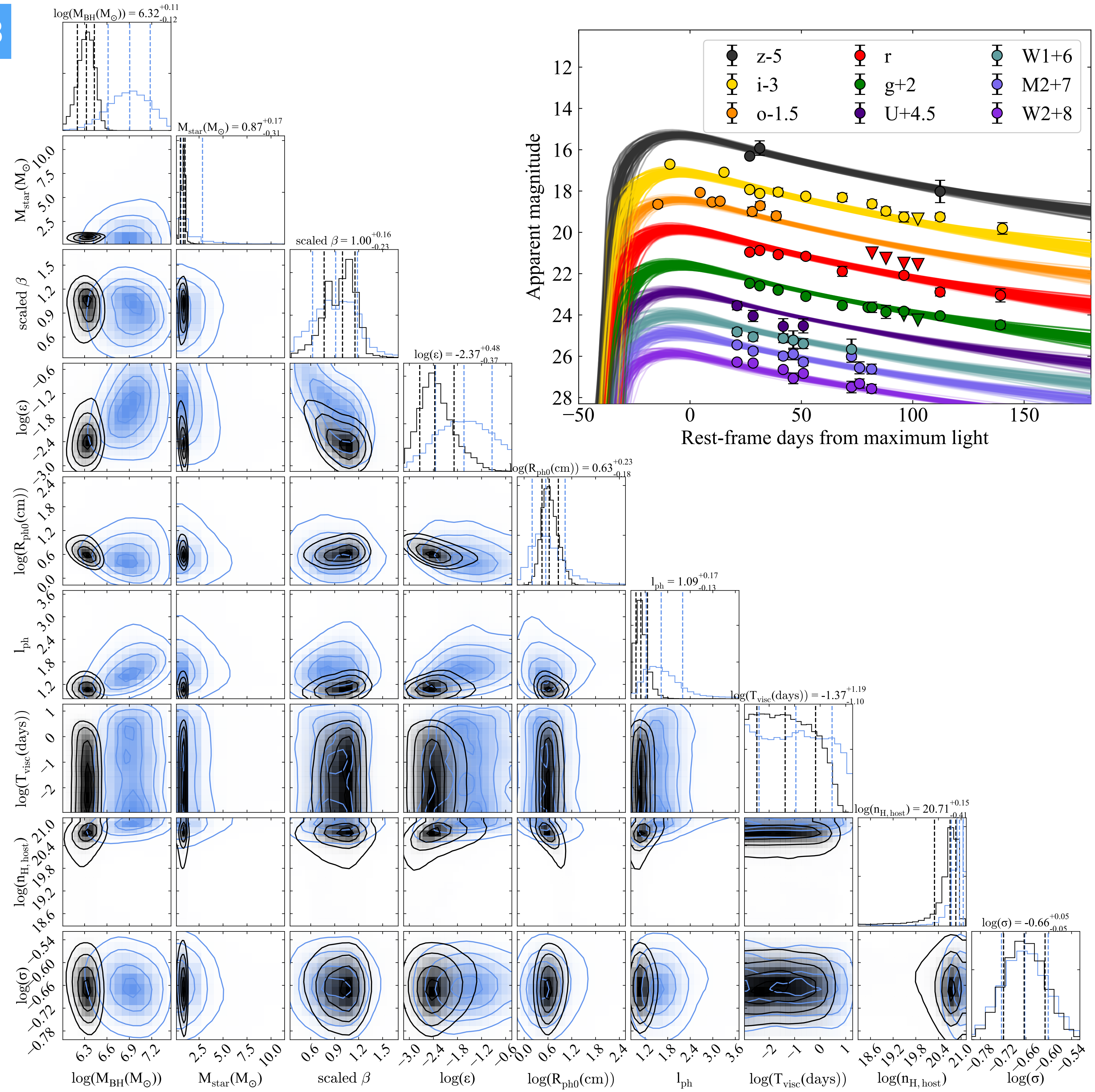
Assuming a typical TDE rise time, we found a SMBH mass $\log(M_h/M_\odot) \approx 6.3$. This value is larger by ~0.5 dex if the rise time is left unconstrained. The disrupted star mass was found to be $\approx 0.9\ M_\odot$. The impact parameter indicates a close encounter (full disruption).

We found no evidence for viscous delays, possibly favouring a collisional (rather than accretion) origin for the luminosity.

We fit the host galaxy SED using Prospector (Leja et al 2017). The total stellar mass indicates an SMBH mass $\log(M_h/M_\odot) \approx 6.8$, consistent with our light curve modelling.

A host spectrum reveals it to be a post-starburst galaxy, overabundant within the TDE sample (French et al 2016). However, it is fainter, and has **a lower stellar mass surface density than any other TDE host except for PS1-10jh (Graur et al 2018).**





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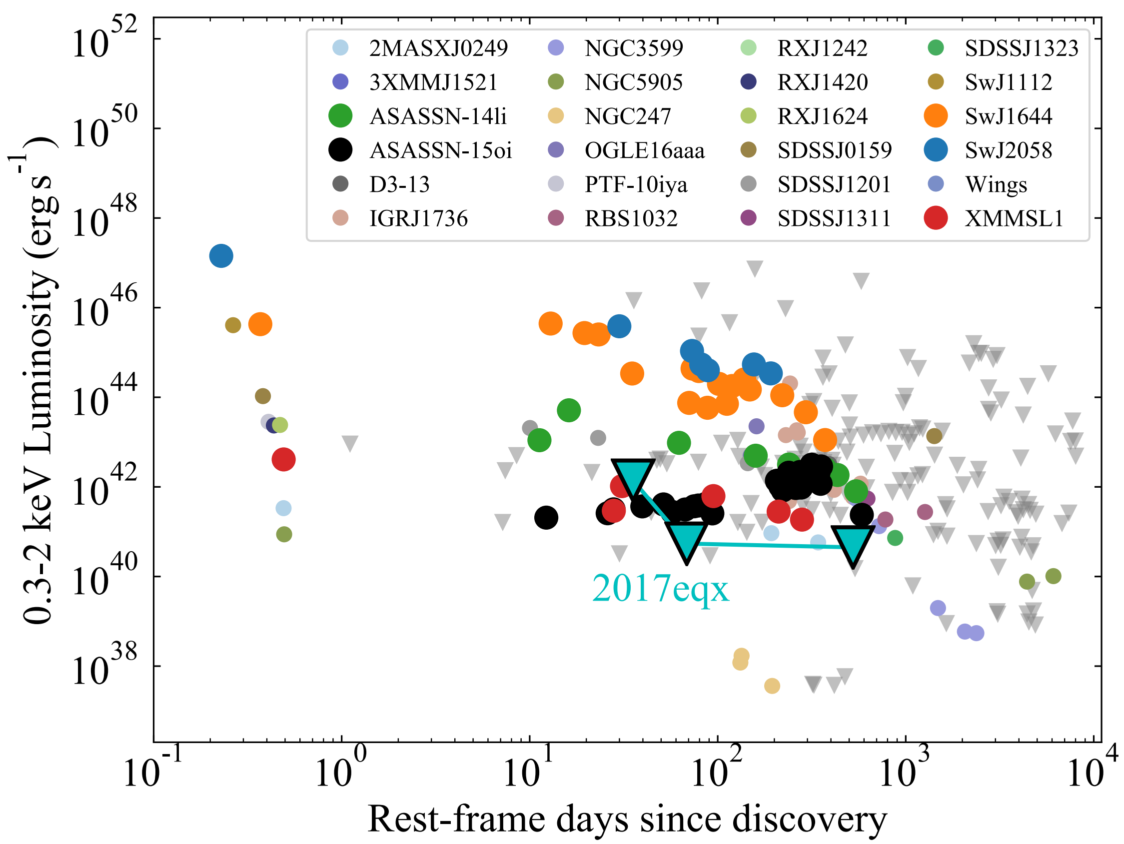
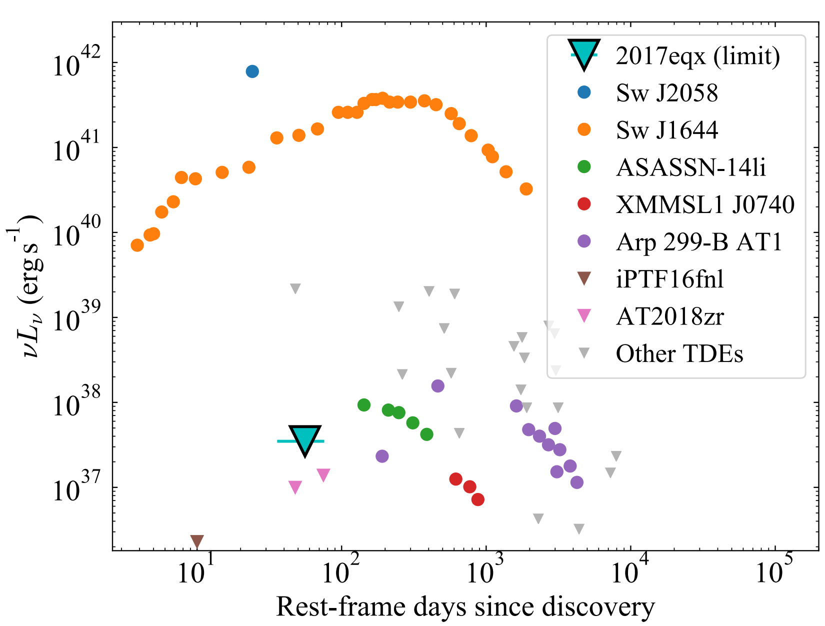




Radio observations with the VLA rule out an on-axis relativistic jet, but may allow a weaker outflow comparable to that seen in ASASSN-14li (Alexander et al 2016, van Velzen et al 2016).

Future radio observations should determine whether this TDE could have launched an off-axis jet

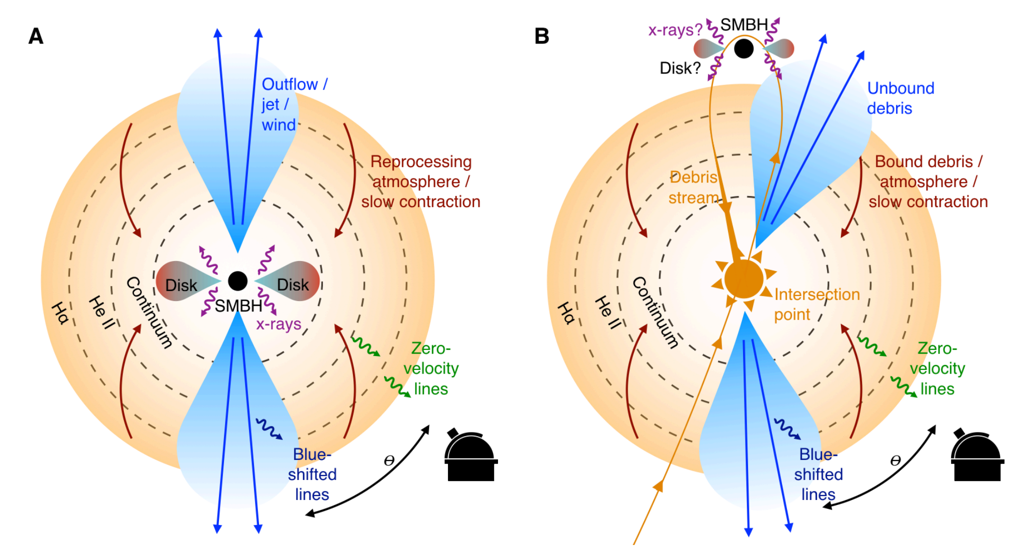
We carried out deep X-ray observations using the Neil Gehrels *Swift* Observatory and *Chandra* X-ray observatory. No X-rays were detected down to a deep limit of < 10^{41} erg/s. one of the deepest limits among TDEs (Auchettl et al 2017)

The lack of X-rays indicates either:

- An optically-thick reprocessing layer, if the TDE is powered by accretion (A). Comparing this to our schematic model, X-rays may have been visible in this case for viewing angles closer to the pole
- A TDE powered by stream-stream collisions/circularisation, rather than direct accretion. In this scenario, a disk may or may not form at late times. If this occurs, a more isotropic emission is expected (B), though it may be faint

We argue that if most TDEs are powered by accretion, there should exist a correlation between X-ray-bright TDEs and blue-shifts in their emission lines, because both are more visible for polar viewing angles.

In a stream-powered scenario, no such correlation exists. Therefore a combination of deep X-ray observations and optical spectroscopy key to revealing the TDE power source



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