A Late-Time Radio Flare Following a Possible Transition in Accretion State in the TDE AT 2019azh

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Abstract

We report high cadence 15.5 GHz follow-up observations of the optical Tidal Disruption Event (TDE) AT 2019azh with the AMI-LA telescope. Our radio observations show an early rise in radio emission that plateaus, followed by a late-time flare (of $\nu L_\nu \sim 10^{38}\,\mathrm{erg\,s^{-1}}$) at around ~ 200 days after optical discovery. Our radio observations in tandem with previously reported late-time soft X-ray flare show similar behavior to the transition in accretion state observed in black hole X-ray binaries (XRBs). We emphasize the importance of late-time radio monitoring of TDEs as late-time radio flares might be more common than we think.

Keywords: Tidal Disruption Events, Transient, Supermassive black holes.

Radio – X-ray observations

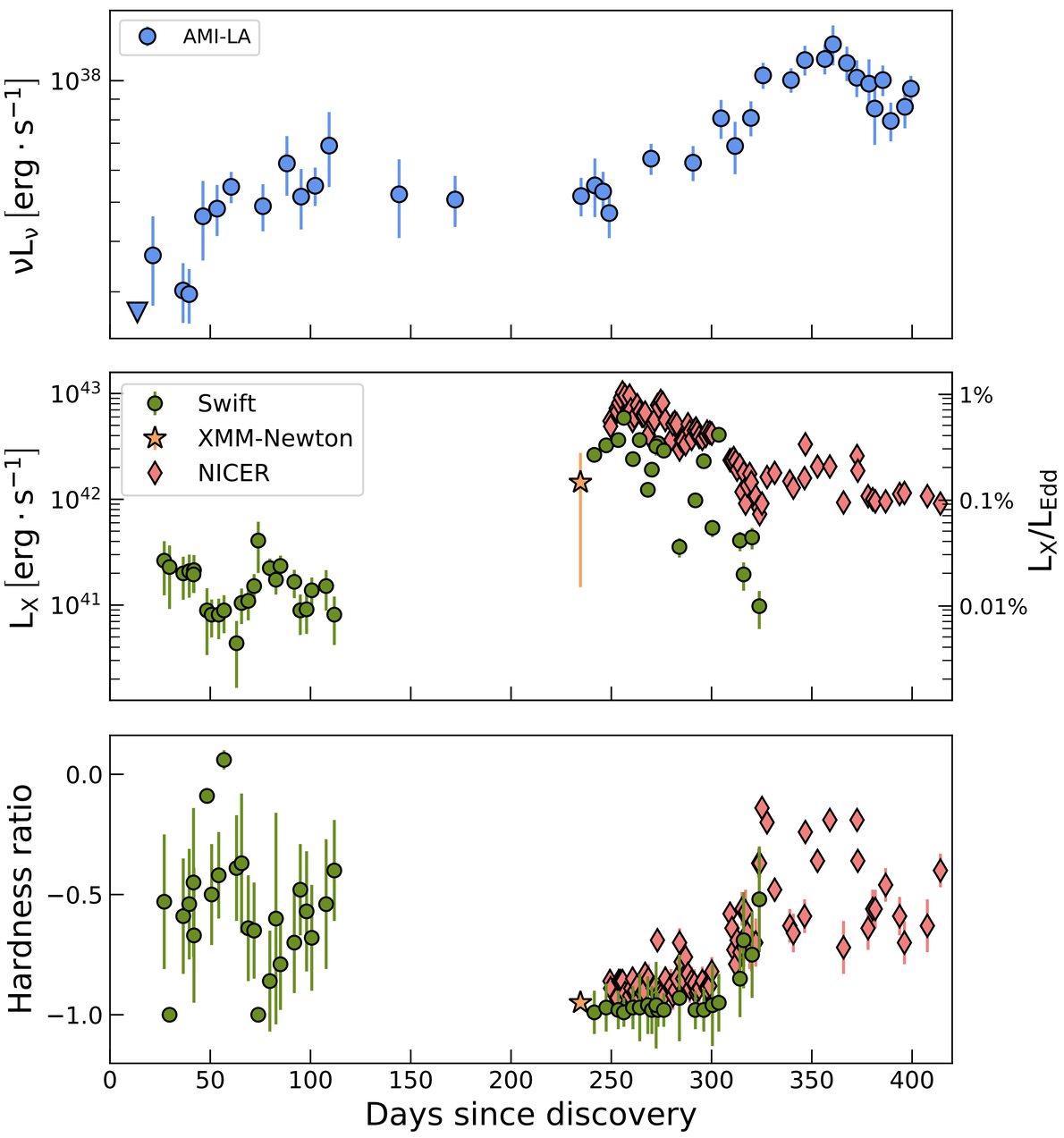

Figure 1: Our AT 2019azh radio observations (top panel), X-ray light curve (middle panel) and, X-ray Hardness ratio (bottom panel). X-ray data from Hinkle et al. (2021).

Hardness-Intensity Diagram

Transition in the accretion state occurs in XRBs when the accretion disc moves in closer to the black hole. This produces an X-ray flare which is followed by a transition from a hard to a soft state. A radio flare, corresponding to a discrete relativistic ejection, is associated with this hard-to-soft state transition. The full cycle of a state transition in an XRB is illustrated in Fig.2. While in the high-soft state (and before the cycle continues to an intermediate-soft state and then to an intermediate-hard quiescent state) XRBs may exhibit several rapid changes (a mini-cycle) between soft and intermediate hard states, while the X-ray emission remains at a relatively high brightness. During these rapid changes, radio flares may also occur. It has also been suggested that accretion state transition, such as observed in XRBs, occurs in a similar manner in AGNs. We observe similar behavior in the combined radio and X-ray data of the TDE AT 2019azh.

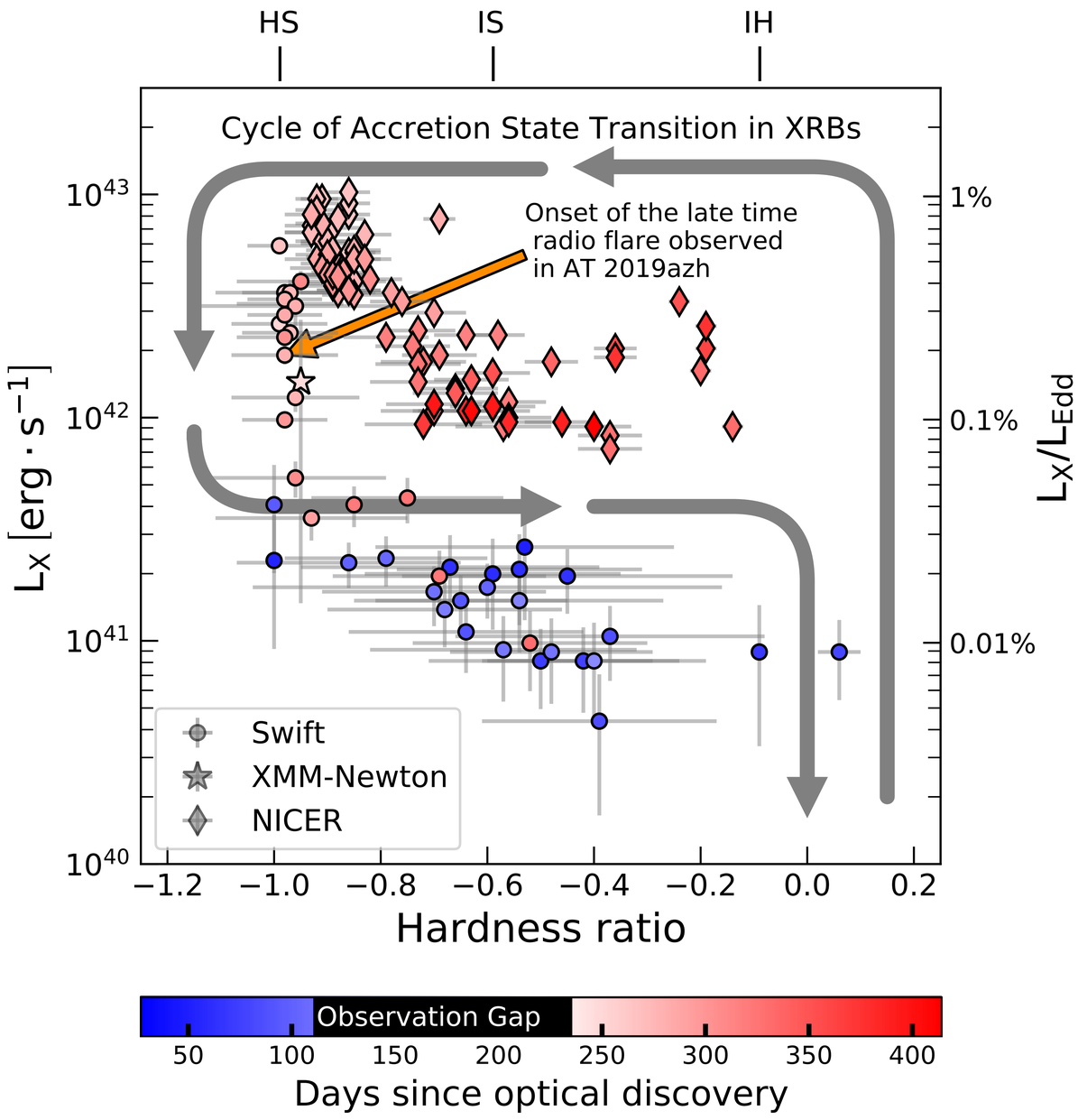

Figure 2: AT 2019azh X-ray luminosity as a function of its hardness ratio as reported by Hinkle et al. (2021). The X-ray data are color-coded by the observation time. Arrows showing the general schematic behavior of the disk-jet coupling observed in XRBs (Fender et al. 2004) are plotted for reference. The start time of the observed 15.5 GHz flare is marked for reference (orange arrow).

TDEs Comparison

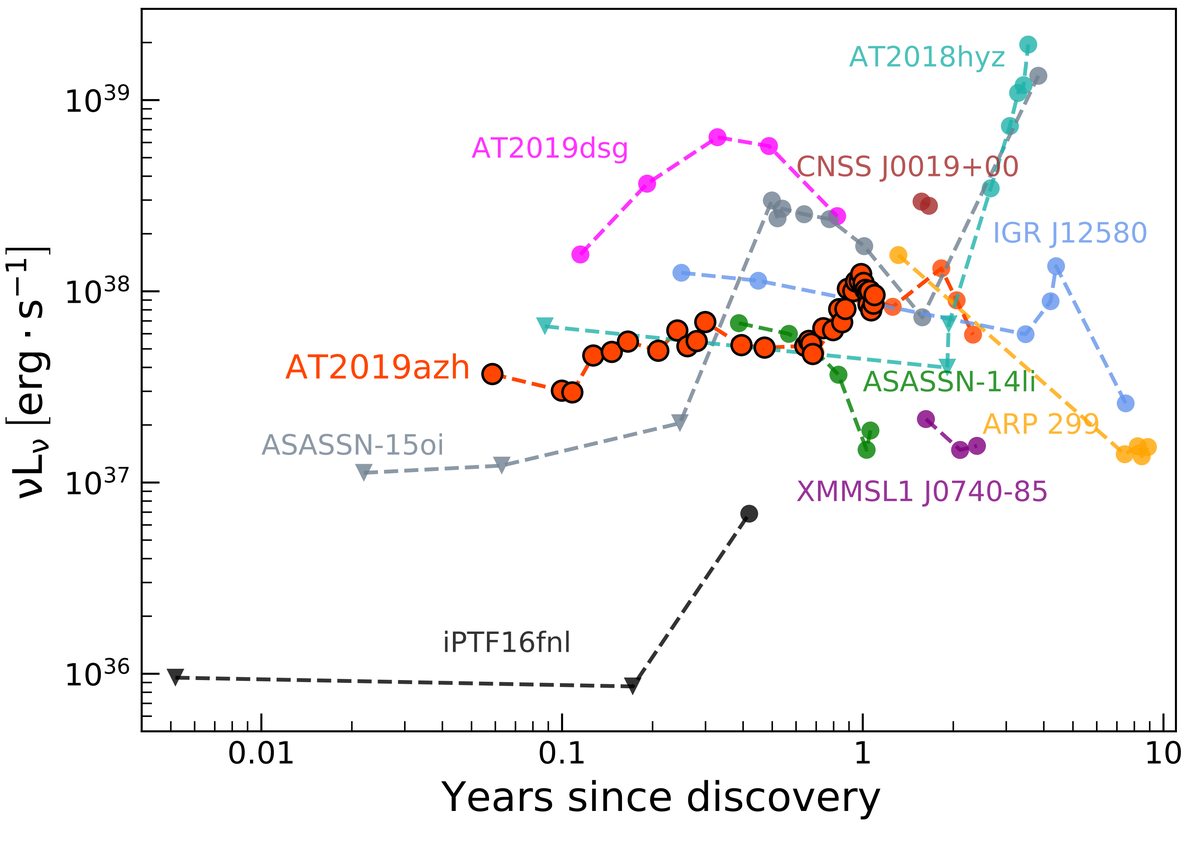

Figure 3: Radio light curves of AT 2019azh (15.5 GHz in red markers with black borders; Sfaradi et al. 2022) and of other TDEs. Also shown, for reference, is the 9 GHz light curve of AT 2019azh (Goodwin et al. 2022; red markers without borders). The only TDEs showing delayed radio flares are ASASSN-15oi (Horesh et al. 2021a), iPTF16fnl (Horesh et al. 2021b), IGR J12580 (Perlman et al. 2022), and, AT2018hyz (Cendes et al. 2022). ASASSN-15oi also shows a secondary flare at later times.

Conclusions

- High cadence radio observations with the AMI-LA show a fast-evolving radio flare. While sparse broadband observations are also key for understanding the nature of the radio emission (see Goodwin et al. 2022), high cadence observations are crucial as flares, such as observed in AT 2019azh, might be missed by those sparse observations.
- The radio flare observed with AMI-LA followed an X-ray flare and a transition from a hard to soft X-ray spectrum. This show similarities to the transition in accretion state, followed by radio flare, observed in XRBs and AGNs.
- Late-time (and delayed) radio flares in TDEs might be more common than we think. Thus, late-time, high-cadence, radio observations of TDEs are crucial for the understanding of the underlying mechanism.

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