Accretion Disc Winds in TDEs: Ultraviolet Spectral Lines as Orientation Indicators

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1: Introduction

- Several TDEs exhibit blueshifted, broad absorption lines (BALs) in their rest-frame ultraviolet (UV) spectra (Figure 1).
  - e.g. iPTF15af (Blagorodnova et al. 2019).
- While other TDEs display only broad emission lines (BELs) (Figure 1).
  - e.g. ASASSN14li (Cenko et al. 2016).
- UV spectra of TDEs also share a striking similarity to those of Broad Absorption Line Quasars (BALQSOs), sharing the same UV resonance features (LoBALQSO in Figure 1).
- This same BAL vs BEL phenomenology of TDEs is also observed in BALQSOs and accreting white dwarfs, often interpreted as an orientation effect associated with line formation in an accretion disc wind, e.g. Shlosman & Vitello 1993, Muarry et al. 1995.
- We explore a similar unification scheme for TDEs, presenting synthetic UV spectra for wind-hosting TDEs, produced by our state-of-the-art Monte Carlo ionization and radiative transfer code, PYTHON[6]. Our models cover a wide range of disc wind geometries and kinematics, and also include the effect of wind clumping.
- Some TDEs show enhanced nitrogen but weak carbon lines - similar to the rare nitrogen rich QSOs (Figure 1) – which may result from the disruption of evolved, intermediate mass stars (Kochanek et al. 2016; Yang et al. 2017). We thus consider

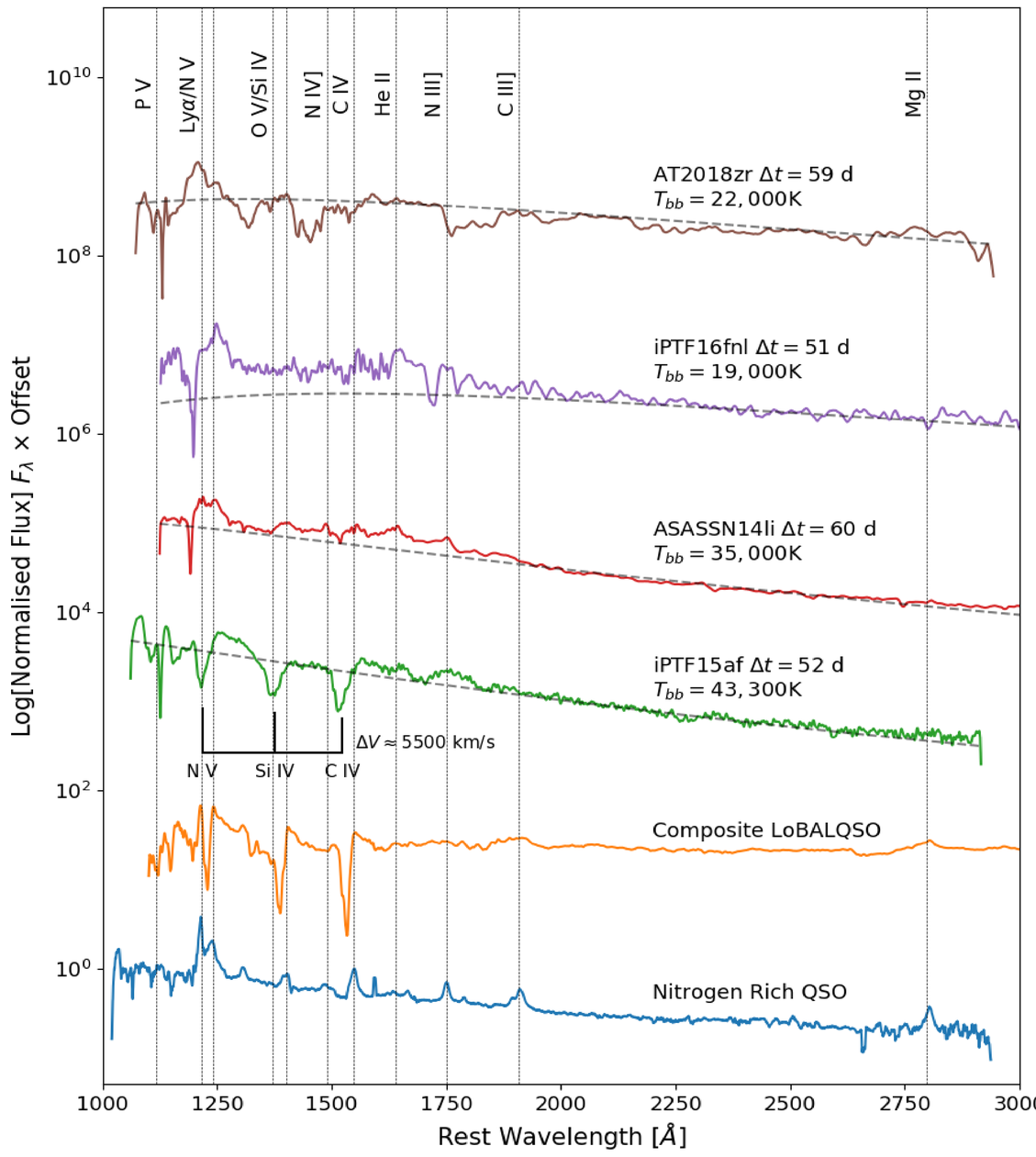

Figure 1: Rest-frame UV spectra of four TDEs iPTF15af (Blagorodnova et al. 2019), ASASSN14li (Cenko et al. 2016), iPTF16fnl (Blagorodnova et al. 2017) and AT2018zr (Hung et al. 2019), as well as UV spectra for a composite LoBALQSO (Brotherton et al. 2001) and and the Nitrogen Rich QSO SDSS J 164148.19 +223225.22 (Batra & Baldwin 2014).

2: Wind Geometries and Model Setup

- We adopt two wind geometries (Figure 2) based on the kinematic Shlosman & Vitello (1993) parameterisation for a biconical accretion disc wind. We create:
  1. A wide-angle polar wind, and,
  2. A narrow equatorial wind.
- The wind is illuminated by a geometrically thin and flat accretion disc, modelled as an ensemble of blackbodies.
  - $M_{BH} \sim 10^7\ M_\odot$; $\dot{M}_{disc} \sim 10^2\ M_\odot/yr$; $R_{disc,in} \sim 10^{13} cm$; $R_{disc,out} \sim 10^{15} cm$
- The wind reprocesses the disc emission but is not a net radiation source.

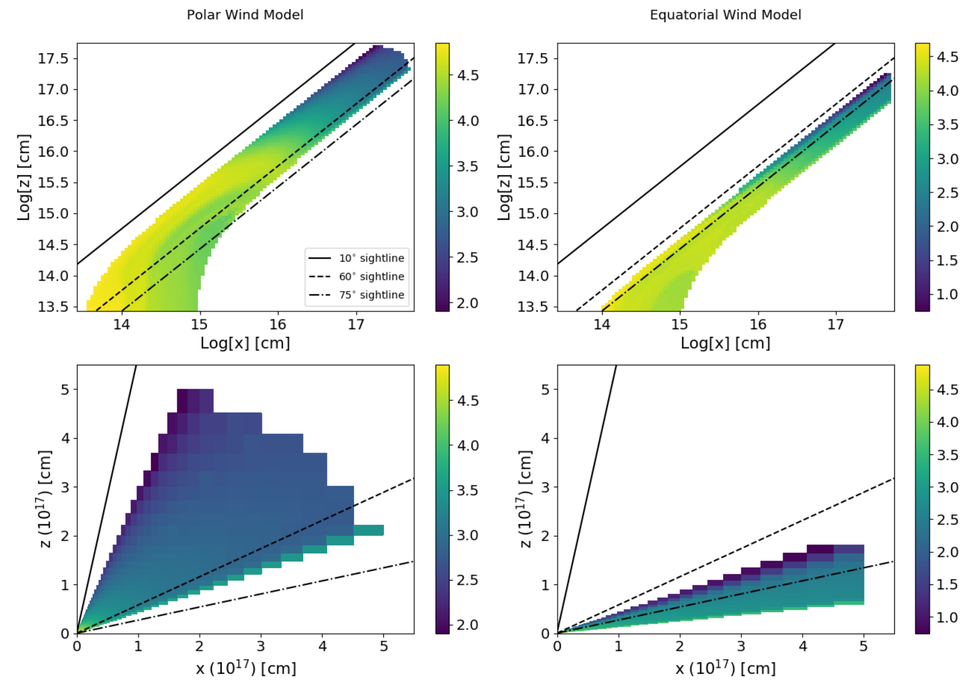

Figure 2: the two wind geometries we adopted on log-log (top) and linear-linear (bottom) scales. The colour map here corresponds to the electron temperature of the wind. Also shown are our three standard sight-lines for spectrum generation.

3: Key Results (Parkinson et al., in prep.)

- The observed diversity of UV line profile shapes (BALs vs BELs) is reproduced by line formation in an accretion disc wind.
  - Sight-lines looking into the wind cone preferentially produce BALs.
  - Other orientations, especially highly edge and face-on sight-lines, which do not look directly into the wind cone preferentially produce BELs.
- Clumping enhances the UV features by lowering the ionisation state of the wind and increasing the abundance of the relevant ionic species.
- Abundance variations do not change the basic UV picture, but can impact line formation by altering the abundance of relevant ions, i.e. weakening of C IV.

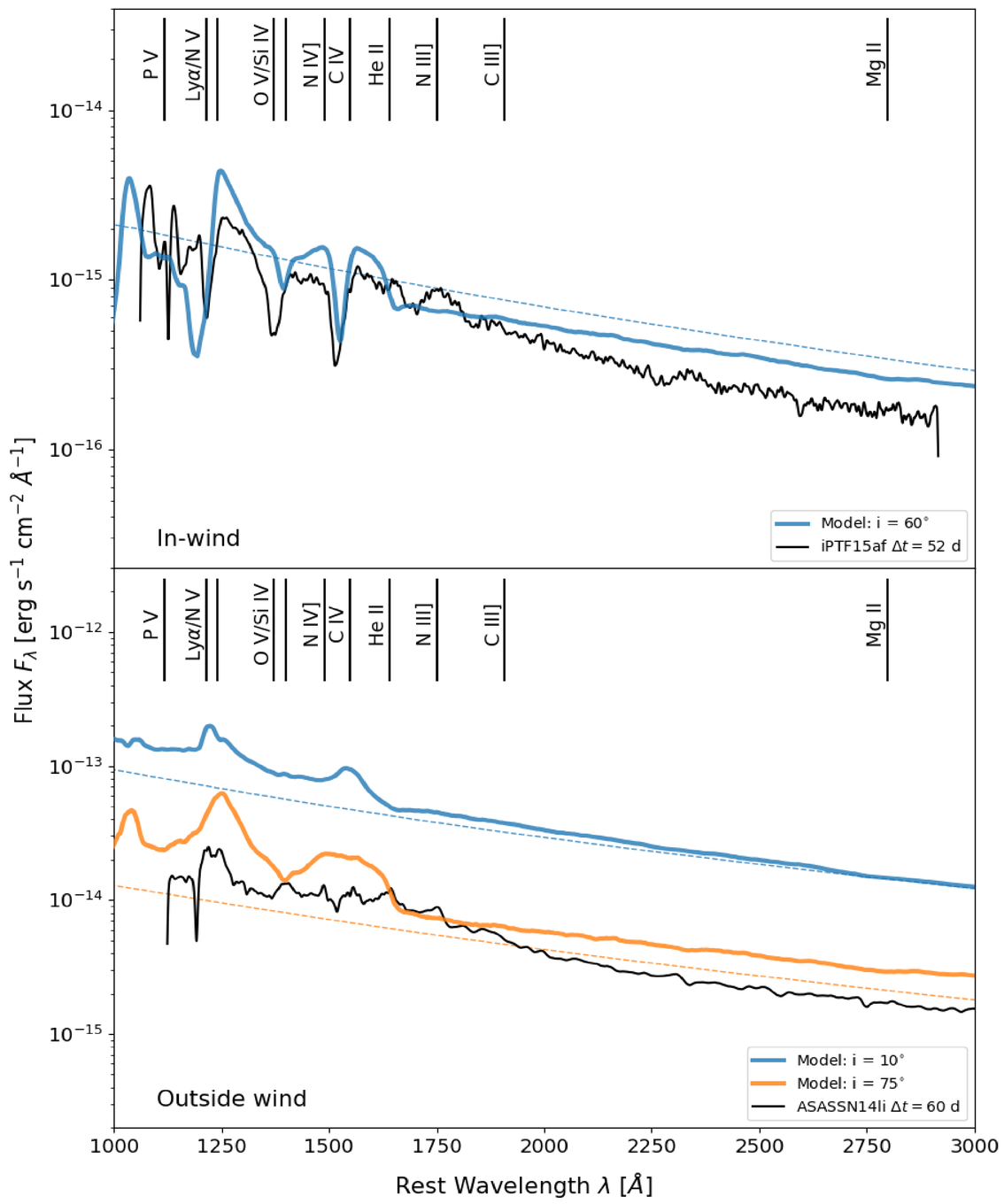

Figure 3: three spectra from our fiducial clumpy polar wind model. Shown is a sight-line looking through the wind-cone (60°) and two more looking face-on (10°) and edge-on (75°) to the accretion disc. Also included are the UV spectra for iPTF15af and ASASSN14li, as well as our disc continuum model. Fluxes have been scaled to the distance of the relevant objects.

4: Conclusions

- Accretion disc winds can offer a natural explanation to the BAL v BEL dichotomy seen in the UV spectra of TDEs.
  - Sight lines looking into the wind-cone produce BALS, and,
  - Other orientations preferentially produce BELs.
- Wind clumping and abundance variations can significantly alter the observed UV spectrum, but do not wholly change the basic picture.
- The relative number of BAL and BEL TDEs can be used to estimate the covering factor of outflows.

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