IOCU 2026 Conference

The 3rd International Online Conference on Universe

4–6 March 2026 | Online

White Dwarfs Mass Accretion in AGN Accretion Disk

Greta H. L. Siu[1], Valentina Sulis[1], Po Kin Leung[1], Kinwah Wu[2,3], Hayden P. H. Ng[4], Joseph G. Read[2], and Ellis R. Owen[5]

1. Department of Physics, Chinese University of Hong Kong, Shatin, N.T., Hong Kong SAR, China
2. Mullard Space Science Laboratory, University College London, Holmbury St Mary, Surrey RH5 6NT, United Kingdom
3. Kavli Institute for the Physics and Mathematics of the Universe (WPI), UTIAS, The University of Tokyo, Kashiwa, Chiba 277-8583, Japan
4. Department of Physics and Astronomy, University College London, Gower Street, London, WC1E 6BT, United Kingdom
5. Astrophysical Big Bang Laboratory (ABBL), RIKEN Cluster for Pioneering Research, Wakō, Saitama, 351-0198 Japan

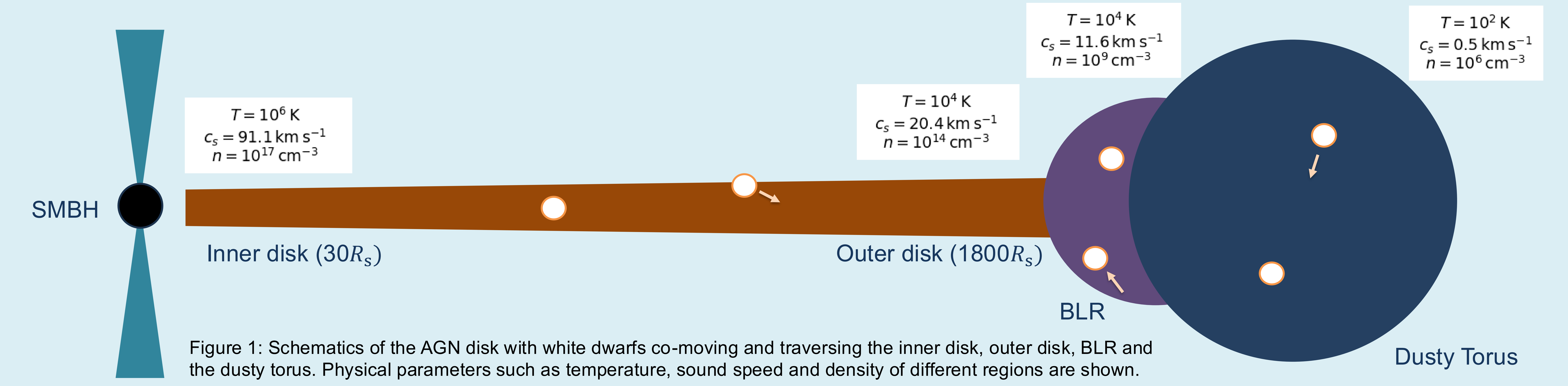

Figure 1: Schematics of the AGN disk with white dwarfs co-moving and traversing the inner disk, outer disk, BLR and the dusty torus. Physical parameters such as temperature, sound speed and density of different regions are shown.

Overview

Low and intermediate-mass stars ($\lesssim 8M_\odot$) end their evolutionary pathways as white dwarfs, compact stellar remnants supported by electron degeneracy pressure. In galactic nuclei hosting actively accreting supermassive black holes (SMBHs), large amounts of gas form a rotationally supported accretion disk, giving rise to an active galactic nucleus (AGN). These AGN accretion disks are dense, gas-rich, and long-lived environments that can support ongoing star formation in their central regions. Consequently, a non-negligible population of white dwarfs may reside within AGN disks, either formed *in situ* through disk star formation or captured when pre-existing white dwarfs traverse into and become embedded in the disk. The AGN disk is dense with hydrogen-rich gas; hence, it provides a natural reservoir for white dwarfs to accrete material and grow in mass. In this work, we investigate the mass growth of white dwarfs embedded in AGN accretion disks across different disk regions.

Representative Model

We consider a central supermassive black hole of mass $10^8 M_\odot$. The AGN disk around it is composed of a thin accretion disk, a broad-line region (BLR), and a dusty torus. We further divide the thin disk into two regions, the inner disk and outer disk, expressed in terms of the Schwarzschild radius R_s. The physical parameters of these regions are labelled in Figure 1.

Accretion of white dwarfs can happen in these 4 regions. In each one of them, we assume the white dwarfs accrete gas spherically, hence the accretion rate $\dot{M}$ is modelled using the Bondi-Hoyle-Lyttleton (BHL) prescription, which gives:

$$\dot{M} = \lambda 4\pi \frac{(GM_{\rm WD})^2(\mu n m_{\rm p})}{(v_{rel}^2 + c_s^2)^{3/2}} ,$$

where $\lambda = 0.1$ is the mass inflow efficiency, $M_{\rm WD}$ is the mass of the white dwarfs, G is the gravitational constant, μ is the mean molecular weight, n is the density of the AGN disk, m_p is the mass of a proton, $v_{\rm rel}$ is the relative velocity between the white dwarf and the AGN disk, and c_s is the sound speed of the AGN disk determined by the temperature.

For each region, $\dot{M}$ for the range of $M_{\rm WD} = [0.2, 1.35]M_\odot$ is calculated. We consider three $v_{\rm rel}$ cases: (1) the white dwarfs comoving with the AGN disk $v_{\rm rel} = 0$, (2) the white dwarfs traversing into the disk with transonic speed $v_{\rm rel} = c_s$, (3) the white dwarfs traversing into the disk with supersonic speed $v_{\rm rel} = 5c_s$.

Moreover, the evolution timescale, which characterizes the time taken for the white dwarf to grow in mass, is calculated with

$$t_{\rm evo} = M_{\rm WD}/\dot{M}.$$

Results

Results of $\dot{M}$ for a range of white dwarf mass and relative velocity across the 4 disk regions are shown in Figure 2, and are compared with the Eddington accretion rate. The results for $t_{\rm evo}$ are shown in Figure 3 for cases where $\dot{M}$ is smaller than the Eddington accretion rate, and $t_{\rm evo}$ is compared with the Hubble time.

Discussions and Implications

1. In most cases, white dwarfs may sustain a relatively high accretion rate in the BLR and the dusty torus. In the inner and outer disk, BHL accretion rate is well over the Eddington limit and hence the actual accretion rate is limited by possible mass loss.
2. It is possible for white dwarfs in the BLR and dusty torus to grow substantially in mass via BHL accretion within the Hubble time.
3. Accreting white dwarfs in AGN environments can reach a mass threshold for the ignition of Type Ia supernovae, and this in turn would also have implications on the chemical enrichment in galactic centers.

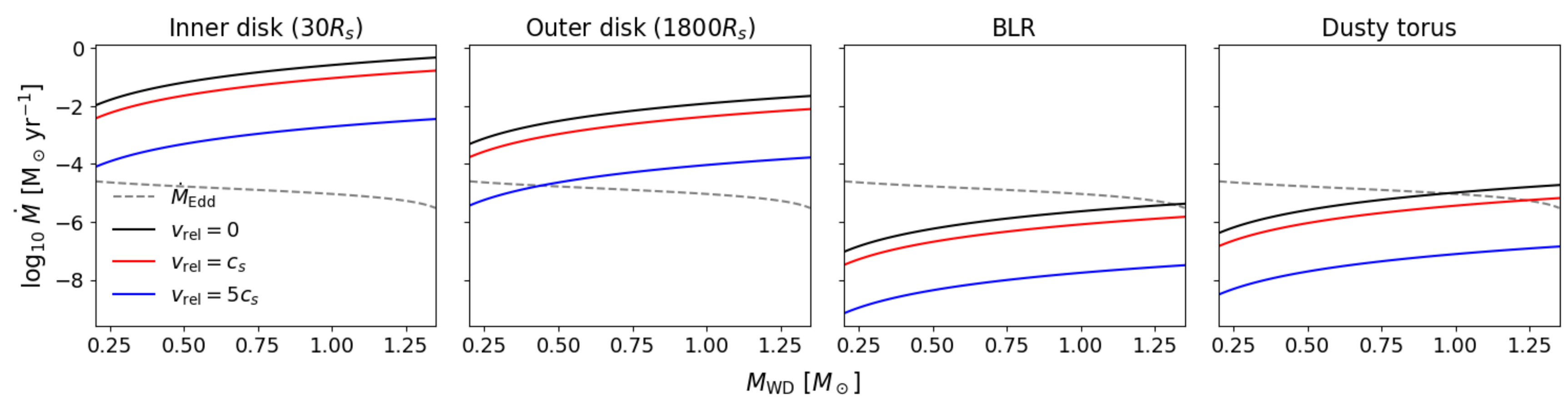

Figure 2: $\dot{M}$ for white dwarfs of various masses travelling at different $v_{\rm rel}$ in different regions of the AGN disk. The gray dotted line shows the Eddington accretion rate over which $\dot{M}$ cannot be sustained due to radiation pressure feedback.

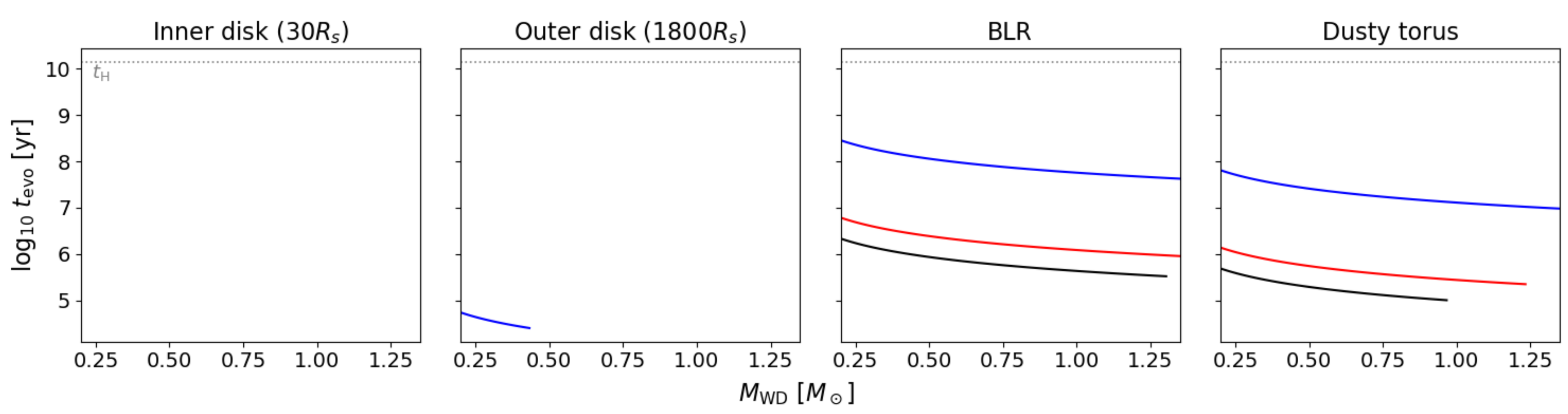

Figure 3: $t_{\rm evo}$ for white dwarfs of various masses travelling at different $v_{\rm rel}$ in different regions of the AGN disk. $t_{\rm evo}$ is only plotted for cases where $\dot{M}$ is smaller than the Eddington accretion rate. The gray dotted line shows the Hubble time of 1.38×10^{10}yr.

References: [1] Peterson, B, 1997, An introduction to Active Galactic Nuclei; [2] Frank, J, King, A, Raine, D, 1992, Accretion Power in Astrophysics; [3] Kilic, M, 2018, MNRAS.479L.113K