Academic Statement

In graduate study, I am most interested in **theoretical astrophysics**. Despite the continuous advancement of observational techniques and the increasing messengers of observations, the natural low occurring rate of TDE has been forcing us to concentrate on the theoretical and simulation research on TDEs. In 2014, motivated by the putative super-Eddington TDE—Swift J1644+57, Prof. **Eric R. Coughlin** proposed a model named Zero-Bernoulli Accretion (ZEBRA) flow. Instead of forming a thin disk, the inflowing gas traps energy and inflates into a quasi-spherical structure, creating a weakly bound envelope around the SMBH. They also assume that the accretion energy is released through jets along rotational poles. This conduit of exhausting energy allows us to demonstrate the consistency with some of the observational features of Swift J1644+57. This work is very sophisticated and impressive. I certainly want to continue the modeling of TDE under his supervision in my graduate study. I also read the paper of his student on interpreting the fast repeated TDE by the Hill's Mechanism. It is truly impressive that such a simple model aligns remarkably well with observational data (except for the GW emission rate), making me deeply admire Prof. Eric's keen intuition in theoretical model research. Besides, he is also a regular participant in academic conferences and one of the coordinators in this year's KITP conference on the TDE. Therefore, I am eager to become one of his students and contribute to pushing the boundaries of what we know about high energy astrophysics. My research experience in BH simulation and the project about TDE are very helpful to Prof. Coughlin's research. I am also confident in becoming one of his best students. My story is below.

My journey began during a visit to the Fuxian Lake Solar Observatory in Kunming, where I was introduced to MHD for studying the Sun's interior by Prof. Chun Xia. There, I witnessed how the activity of the Sun influence on Earth. Exploring the application of fluid dynamics during my undergraduate ignited my passion for astrophysics. My excellent academic performance in my freshman year earned me a place in the Fudan University Joint-Cultivated Undergraduate Program. At Fudan, I strengthened my understanding of theoretical physics. Although this program was interrupted by the *2022 Spring Shanghai Lockdown*. I continued pursuing study opportunities at the University of Notre Dame and UC Santa Barbara. These study and research experiences shaped my research taste and laid a foundation for my future academic career.

In my junior year, I initiated a research project on extreme super-Eddington BH accretion in AGN. It is well known that the accreting material piled at the surface of a neutron star or white dwarf will go through thermonuclear fusion and shine in X-ray band. Why is then the accreting black hole cannot induce such a burst? What is the difference between a black hole accretion and a neutron star? On the other hand, fast accretion BH is thought to form in the disk of AGN. Small BH mass with a fast accretion will bring a hotter and denser ambient. Based on these questions and analysis, we started from the basic advection-dominated accretion flow model and explored the effect of thermonuclear fusion on fast accretion. In energy equation, we considered the heat released by two types of hydrogen burning and Helium burning. In order to learn more about nuclear reactions, I studied advanced courses at UCSB as an exchange student. I was also introduced to the Modules for Experiments in Stellar Astrophysics (MESA). After I returned, with my supervisor's help, I developed a 4th-order Runge-Kutta method using Python to solve the disk structure. The result shows that heat released by fusion is still negligible, mainly due to the low density and high advection cooling rate. After our discussions, my answer to the initial question is that BH has no clear physical surface to deposit the material and therefore, cannot make it as dense as those in NS or WD. After that, I decided to employ an open-source code(the workhorse of MESA) to compute the nuclear reaction network. Significant metal enrichment has been reproduced. If these elements are carried by the outflow of the disk, we may explain the supersolar metallicity observed in the broad line region. During this research, I greatly enhanced my skills in numerical simulation and parallel computing on a Linux server. This work culminated in a paper accepted by *MNRAS* (See the link).

In the summer of 2023, I participated in the International Summer Undergraduate Research Experience at the University of Notre Dame, where I worked with Prof. Boja Anguiano to study the kinematical and chemical properties of the M33 galaxy. Using spectra of approximately 100 clusters obtained with the Hectospec instrument at the MMT Observatory, I processed the data with Python to classify the clusters into young($\lesssim 3 \times 10^8$yr), intermediate and old($> 8 \times 10^8$yr) populations. Subsequently, I calculated metallicity, velocity, and spatial distributions to identify statistical patterns. Our analysis revealed that young clusters are more metal-rich ([Z/H] ~ -0.1), while older clusters exhibit greater scatter in metallicity and weaker correlations with age. Furthermore, we observed that the velocity dispersion relative to local disk motion increases with cluster age, and rotational velocities decline with age. This experience allowed me to understand the typical workflow of data analysis in astronomy, as well as the importance of observational study in guiding theoretical research.

In this fall quarter, I finished two graduate courses with grade *A* in UCSB; one was High Energy Astrophysics conducted by Prof. Omer Blase. I also finished a course project entitled Repeated TDEs(link). I surveyed the observational and theoretical progress in explaining repeated TDEs and concentrated on the promising models. Hills Mechanism and Kozai-Lidov Mechanism are two promising directions, both trying to introduce a third body's perturbation to drag the star near the disruptor. This course has not only pushed me to the most cutting-edge and active research directions in the field but also deepened my understanding of radiation mechanisms in high energy astrophysics. I also finished a course project related to planet formation theory under the instruction of Prof. Ben Mazin at UCSB (link)

In addition to astrophysics, I am also interested in condensed matter physics. I conducted a project entitled Phase Transitions in the 2D Ising Model with Prof. Bo Zheng. Using Monte Carlo method, I simulated the Paramagnetism-Ferromagnetism transition of the system using Python. I analyzed the order parameters of the system and compared the convergence and robustness of two strategies. I also made an animation that shows the transition of the symmetry breaking of the lattice. I believe that my solid theoretical foundation and multidisciplinary research experience will greatly benefit me in my future study.

Overall, the Virginia Institute of Theoretical Astronomy and the Department of Physics at Virginia offer a broad range of research topics pursued by various scholars. This interdisciplinary environment fosters intellectual stimulation and encourages collaboration across different fields, enabling us to tackle scientific challenges in unexpected and innovative ways. Therefore, I am deeply enthusiastic about starting my graduate studies at the University of Virginia. In the long run, I am going to be a theoretical astrophysicist aspiring to build models that better align with observational data and adhere more closely to physical intuition.