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My main research interests include Astrophysics and Astronomy, in particular, radio astronomy, binary evolution and galaxy formation. I am currently studying in Mphys(Hons) program at University of Manchester (UoM). I graduated in ***Tsien Hsue-shen Talent Program*** (top 10% students) at Xi'an Jiaotong University (XJTU) and have been involved in the following research activities:

1. I was working with Prof. Zhaoyu Zuo at XJTU and lead a team doing research about super fast X-ray transients. Then I study on Ultra-luminous X-ray Sources (ULXs). I published an article on wind accreting ULXs with neutron star on *Astronomy & Astrophysics* **[1],** and write a manuscript on ULXs population synthesis in Ring galaxies **[2]**.

2. I was working with Texas A&M University (TAMU) under the supervision of Prof. Marlan Scully. I submitted article to *Scientific Reports* **[3]** as the first author. At the moment, I am working on manipulating speckles via deep learning approach **[4]**.

3. Currently, I am working with Prof. Ian Browne at UoM on "Galaxies alignments" and Prof. Anna Scaife on "hierarchical Fanaroff-Riley classification".

At beginning, I lead a team conducting research on Super X-ray Transients(SFXTs). I generally acquire the characteristics of SFXTs and learned popular mechanism explaining SFXTs. Motivated by this, I started my research on ultra-luminous X-ray sources(ULXs) under the supervision of Prof. Zuo. We found that some X-ray sources are impossible to be ULXs via Roche-lobe overflow in binary system, and simulation on Wind Roche-lobe overflow (WRLOF) reveal a brand-new possible mass-transfer mechanism for ULXs. I utilize an evolutionary population synthesis method to testify WRLOF in ULXs **[1]**. Accumulating ULXs experience during the first project, I generally learned how to build sophisticated simulations and have already fostered a habit of reading papers regularly. I started to focus on ULXs in Star-burst galaxies and combined WRLOF and Roche-lobe overflow. Population synthesis displayed WRLOF contributed partly to ULXs and coincide with Observation in several Ring Galaxies **[2]**.

To broaden my knowledge, I attended a summer school at the Peking University, China. My visit was sponsored by XJTU. I gave a talk on Machine Learning on Physics during the summer school. From this program, I realized that a good researcher should comprehend a broad spectrum of information to gain insight. This program inspired my interest in quantum optics. I began to dabble in machine learning and started AMO projects with TAMU.

I was working on the Computational GI (CGI) at TAMU last year and collaborated with professors and postdocs. The large sampling number is the main disadvantage of CGI compared to the conventional photography, I proposed to combining Deep Learning and pink noise to achieve extremely low sampling number (0.8% Nyquist limit). I built the CNN framework, simulated CGI process, and conducted experiment via remote control. Then I wrote a first-handed manuscript **[3]**. Inspired by convolutional process in CNN, I conceived that convolutional kernel could generate speckles. I built an unprecedented workflow for Deep Learning process and successfully retrieve complicated objects in lower sample rate **[4]**. Moreover, I collaborated with Prof. Zhedong Zhang, City University of HongKong. I programmed workflow for deep-learning process and contributed to the idea of structure of Deep-Learned Time-Resolved Coherent Raman Spectroscopy **[5]**.

Apart from doing research, I joined lots of competition to broaden my knowledge. I was awarded of **First Prize** of the 5th Chinese Undergraduate Physics Experiment Competition which significantly improve my experimental skills. I also won **First Prize** of the Contemporary Undergraduate Mathematical Contest in Modeling in ShaanXi province as team. I learnt the importance of teamwork and communication. Moreover, I always eager to attend seminars and

meetings. There I have learned how other researchers conduct experiments and inspire my creativity and innovation in my research area.

Currently, I am doing research with Prof. Ian Browne and Prof. Anna Scaife at University of Manchester. For the hierarchical Fanaroff-Riley classification of radio galaxies, I built branch convolutional neural network and optimize the loss function for better performance. In Galaxy alignment, I access the SDSS and FIRST original catalog, and enlarge the samples for radio and optical galaxies alignments.

My academic and research experiences gained in Astronomy, quantum optics and machine learning, have provided unique insights and clarified my career goals. I am eager to learn physics and disciplines needed, and to become a physicist.

[1]. Z. Zuo†, **H. Song**, H. Xue, "Population synthesis on ultra-luminous X-ray sources with an accreting neutron star: Wind Roche-lobe overflow cases". A&A 649, L2 (2021)
[2]. **H. Song**, Z. Zuo†, "Ultra-luminous X-Ray sources with wind Roche lobe overflow in Ring galaxies".
[3]. **H. Song**, X. Nie, H. Su, H. Chen, Y. Zhou, X. Zhao, T. Peng†, M. O. Scully, "0.8% Nyquist noise-free computational ghost imaging via non-experimental deep learning", submitted to Scientific Report, arXiv:2108.07673
[4]. X. Nie, **H. Song**, T. Peng†, Z. Zhang†, and M. O. Scully, "Deep-learned speckle patterns and its application to ghost imaging".
[5]. X. Nie, Y. Ma, Z. Han, **H. Song**, T. Peng†, Z. Zhang†, and M. O. Scully, "Deep-Learned Time-Resolved Coherent Raman Spectroscopy".