ZeyuanXuan

Department of Physics and Astronomy, UCLA
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EDUCATION

Ph.D., Physics, Univeristy of California, Los Angeles, USA. 2023-Present
Advisor: Smadar Naoz

M.S., Physics, Univeristy of California, Los Angeles, USA. 2021-2023
Advisor: Smadar Naoz

B.S., Physics, Peking University, China. 2017-2021
Advisor: Xian Chen

Awards and Honors

- Mani L. Bhaumik Graduate Fellowship in Theoretical Physics 06/2023
- Mani L. Bhaumik Graduate Fellowship in Theoretical Physics 06/2022
- Cross-disciplinary Scholars in Science and Technology, UCLA 03/2020
- Scholarship of Peking University 10/2019
- National Scholarship 12/2018
- Merit Student, Peking University 12/2018
- 1st Prize in National Physics Competition for College Students 11/2018

PUBLICATION

- **Zeyuan Xuan**, Smadar Naoz, Bence Kocsis and Erez Michaely. *Stochastic Gravitational Wave Background from Highly-Eccentric Stellar-Mass Binaries in the Milli-hertz Band, arXiv:2403.04832. (2024)*
- **Zeyuan Xuan**, Smadar Naoz, Bence Kocsis and Erez Michaely. *Detecting Gravitational Wave Bursts From Stellar-Mass Binaries in the Milli-hertz Band, The Astrophysical Journal. (2023)*
- **Zeyuan Xuan**, Smadar Naoz and Xian Chen. *Detecting Accelerating Eccentric Binaries in the LISA Band, Physical Review D. (2023)*
- **Zeyuan Xuan**, Peng Peng and Xian Chen. *Degeneracy between mass and peculiar acceleration for the double white dwarfs in the LISA band, Monthly Notices of the Royal Astronomical Society.(2021)*
- Chen, Xian; **Xuan, Ze-Yuan**; Peng, Peng. *Fake Massive Black Holes in the Milli-Hertz Gravitational-wave Band, The Astrophysical Journal.(2020)*
- Torres-Orjuela, Alejandro; Amaro Seoane, Pau; **Xuan, Zeyuan**; Chua, Alvin J. K.; Rosell, Mara J. B.; Chen, Xian. *Exciting modes due to the aberration of gravitational waves: Measurability for extreme-mass-ratio inspirals, Physical Review Letters.(2020)*

RESEARCH EXPERIENCE

Stochastic Gravitational Wave Background from Highly-Eccentric Binaries in the LISA Band 10/2023-03/2024
Cooperative research, with Prof. Smadar Naoz, Prof. Bence Kocsis, and Dr. Erez Michaely

- Summary of the project:
  Dynamical interactions can bring a binary with large initial orbital separation into a close pericenter passage, leading to efficient GW emission and a final merger. As a progenitor stage of these mergers, highly eccentric compact object binaries may commonly exist in our Universe. In this work, we examine the stochastic GW background (GWB) from highly eccentric, stellar-mass sources in the mHz band. Our findings suggest that these binaries can contribute a substantial GW power spectrum, potentially exceeding the LISA instrumental noise at 3~7 mHz.

Detecting Gravitational Wave Bursts From Stellar-Mass Binaries in the Milli-hertz Band 12/2022-10/2023
Cooperative research, with Prof. Smadar Naoz, Prof. Bence Kocsis, and Dr. Erez Michaely

- Summary of the project:
  For the wide eccentric compact object binaries, the GW emission happens mostly near the pericenter passage, creating a unique, burst-like signature in the waveform. We show that the number of millihertz bursting sources can be large in the local universe. For example, based on our estimates, there will be ~ 3−45 bursting binary black holes in the Milky Way, with ~ 10^2−10^4 bursts detected during the LISA mission. Moreover, we find that the number of bursting sources strongly depends on their formation history. If certain regions undergo active formation of compact object binaries in the recent few million years, there will be a significantly higher bursting source fraction.

Detecting Accelerating Eccentric Binaries in the LISA Band 11/2021-10/2022
Cooperative research, with Prof. Smadar Naoz and Prof. Xian Chen

- Summary of the project:
  We show that eccentricity can greatly enhance the measurement of Gravitational Wave sources' peculiar acceleration, as the general relativistic precession pattern can disentangle the acceleration-induced frequency shift from the chirp-mass-induced frequency shift in (milli-hertz) GW template fitting. By adopting the GW templates of the

accelerating eccentric compact binaries, we can enhance the acceleration measurement accuracy by a factor of ~100, compared to the zero-eccentricity case, and detect the source's acceleration even if it does not change during the observational time.

Degeneracy between mass and peculiar acceleration for the double white dwarfs in the LISA band 01/2020-02/2021

Cooperative research, with Prof. Xian Chen & Peng peng,

- Summary of the project:
  We showed that due to the large number and small mass of Double White Dwarfs (DWDs) in the Milky Way, there may be ~400 DWDs detected by LISA whose GW signals are severely affected by acceleration induced by a tertiary. These sources' parameters are strongly biased while this effect can hardly be distinguished, and they may be mistaken as BBHs or primordial black holes if we do not take acceleration into account.

Gas-induced Fake Massive Black Holes in the Milli-Hertz Gravitational-wave Band 05/2019-06/2020

Independent Research, Supervised by Prof. Xian Chen, Kavli Institute for Astronomy and Astrophysics, Peking University

- Summary of the project:
  This work answered three important questions: 1. To what extend the GW from binary black holes (BBHs) will be affected by gasous environment; 2. How the measured parameters are biased; 3. How long it takes us to distinguish such distorted signal. We showed that when BBHs are in certain gasous environment like the AGN disk, the GW signal will be distorted so severely that such BBHs look like much heavier GW sources, while it take us longer than 5yrs to distinguish these "fake massive black holes".

Beaming effect of gravitational waves induced by the peculiar velocity of the source 06/2020-10/2020

Cooperative research, in the group of Prof. Pau Amaro Seoane

- Summary of the project:
  The beaming effect of GW, which is different from that of light, will result in the change of the relative amplitude of GW's different harmonics, thus distort the signal. This phenomenon can be used to break the well-known "mass-redshift degeneracy", and may become the first way to directly measure the peculiar velocity of GW sources.

CONFERENCES AND TALKS

"Search for repeated burst gravitational wave signals," LISA Sprint 2024, Caltech, 05/2024

"Eccentric sources and their gravitational wave signal in the millihertz band," KIAA-DoA Seminar, PKU, 08/2023

"eXtreme Black Holes," Aspen, 03/2023

TEACHING

Graduate Teaching Associate 12/2022-Present

UCLA Dept. of Physics and Astronomy, Los Angeles, CA

Courses:

• Physics 105B: Analytic Mechanics

• Physics 5C: Electricity, Magnetism, and Modern Physics

Graduate Teaching Assistant 09/2021-12/2022

UCLA Dept. of Physics and Astronomy, Los Angeles, CA

Courses:

• Physics 5C: Electricity, Magnetism, and Modern Physics