# Xiaohan Ma

Center for Space Physics
the Department of Astronomy
Boston University
xhma@bu.edu
https://orcid.org/0000-0003-0007-757X

## EDUCATION BACKGROUND

**BOSTON UNIVERSITY** 09.2020–present
*Center for Space Physics, the Department of Astronomy*
Ph.D. Candidate Major in Astronomy Advisor: Prof. Merav Opher
**PEKING UNIVERSITY** Beijing, China 09.2017–07.2020
*Institute of Space Physics and Applied Technology, School of Earth and Space Science*
Master's Degree Major in space physics Advisor: Prof. Qiugang Zong
**PEKING UNIVERSITY** Beijing, China 09.2013–07.2017
*School of Earth and Space Science* Bachelor's Degree Major in space physics

## RESEARCH INTEREST

My research focuses on exploring plasma instabilities and turbulence in various magnetized plasma environments through three-dimensional magnetohydrodynamic simulations and observations. Currently, I investigate the full evolutionary cycles of Rayleigh–Taylor and Kelvin–Helmholtz instabilities in heliosphere: their initial coupling, quasi-periodic evolution, and nonlinear saturation phases that drive the transition from coherent structures to fully developed turbulence.

***Keywords: Plasma instabilities • Plasma turbulence • Magnetohydrodynamical simulations***

## PUBLICATIONS

Ma X, Opher M, Kornbleuth M. The Coupling and Evolution of Kelvin–Helmholtz and Rayleigh–Taylor Instabilities in the Heliosheath[J]. The Astrophysical Journal, 2025, 988(2): 248.

Ma X, Opher M, Kornbleuth M, et al. Instabilities along the Axis of the Heliospheric Jets[J]. The Astrophysical Journal, 2024, 978(1): 57.

Ma X H, Zong Q G, Yue C, et al. Energetic electron enhancement and dropout echoes induced by solar wind dynamic pressure decrease: The effect of phase space density profile[J]. Journal of Geophysical Research: Space Physics, 2021, 126(3): e2020JA028863.

Ma X H, Zong Q G, Liu Y. The intense substorm incidence in response to interplanetary shock impacts and influence on energetic electron fluxes at geosynchronous orbit[J]. Journal of Geophysical Research: Space Physics, 2019, 124(5): 3210-3221.

## RESEARCH EXPERIENCE

**Research on the Development and Consequences of Instabilities in Heliosheath**

*Individual project, Supervised by Prof. Opher (Boston University)* present

- Discovered and confirmed Kelvin–Helmholtz instability in the heliosheath, offering new insight into how instabilities shape heliospheric dynamics.
- Modeled the heliosphere under realistic interstellar medium conditions with a single-ion (SI) MHD model, uncovering the periodic growth and later decoupling of Rayleigh–Taylor and Kelvin–Helmholtz instabilities.
- Demonstrated that the nonlinear growth of these instabilities drives turbulence and can lead to heliotail separation, improving understanding of large-scale plasma evolution.

**Research on Development of Rayleigh-Taylor-Like Driven Instability in Heliosheath with a Multi-Ion treatment**

*Individual project, Supervised by Prof. Opher (Boston University)* 09.2021-12.2022

- Applied a multi-ion (MI) MHD model, treating cooler thermal solar wind ions and hotter pickup ions (PUIs) as separate fluids, to study the impact of PUIs on Rayleigh–Taylor instability.
- Calculated Rayleigh–Taylor instability growth rates in the MI model and compared them with SI model results, highlighting differences in instability behavior.

**Research on the impact of sudden drop of solar wind dynamic pressure on energetic electrons in the inner magnetosphere**

*Individual project, Supervised by Prof. Qiugang Zong (Peking University)* 09.2018-03.2020

- Analyzed satellite observations and conducted statistical studies of electron drift echoes, identifying patterns that distinguish, revealing underlying occurrence trends.
- Demonstrated that electron phase space density is a key driver of energetic electron flux variations during dynamic

pressure decreases, providing new insight into particle behavior under changing space weather conditions.

**Research on warm plasma cloak particle dynamis in the inner magnetosphere**

*Individual project, Supervised by Prof. Jacob·Bortnik (University of California, Los Angeles)* 07.2019–09.2019

- Developed neural network models to forecast plasma distributions from satellite time-series data, achieving up to 97% accuracy in quiet and 90% in disturbed conditions.
- Created a 2D spatial model of warm plasma cloak particle distributions and visualized their temporal evolution, enabling deeper insight into magnetospheric dynamics.

**Research on the intense substorm incidence in response to interplanetary shock impacts and influence on energetic electron fluxes at geosynchronous orbit**

*Individual project, Supervised by Prof. Qiugang Zong (Peking University)* 12.2016–03.2018

- Conducted statistical analysis of interplanetary magnetic field pre-conditions during substorms, identifying key factors influencing magnetospheric activity.
- Validated the impact of interplanetary shocks on the Auroral Electrojet index and electron dynamics, providing new insights into space weather coupling processes.

## PRESENTATION EXPERIENCE

**Oral Presentation**

- 'The Coupling and Evolution of Kelvin-Helmholtz and Rayleigh-Taylor Instabilities in the Heliosheath', *Solar Science Meeting, Smithsonian Astrophysical Observatory, Center for Astrophysics | Harvard & Smithsonian, 09.2025*
- 'The Coupling and Evolution of Kelvin-Helmholtz and Rayleigh-Taylor Instabilities in the Heliosheath', *Engineering-Physics Space Plasma Seminar Spring 2025, Dartmouth College, 06.2025*
- *'Instabilities in the Heliosheath'., SHIELD 2025 Annual Meeting, 03.2025*
- 'Electron drift echoes induced by negative solar wind dynamic pressure pulses', *European Geosciences Union (EGU), online, 05.2020*
- 'The intense substorm incidence and influence on Energetic electron in response to interplanetary shock impacts', *Fundamental Physical Processes in Solar-Terrestrial Research and Their Relevance to Planetary Physics, Hawaii, USA, 01.2018*

**Poster Presentation**

- 'Instabilities along the axis of the Heliospheric Jets', Xiaohan Ma, Merav Opher, Marc Kornbleuth, Gabor Toth
  *American Geophysical Union (AGU) Fall Meeting 2024 Washington, D.C., USA. 12.2024*
- 'Condition for the Development of Instability along the Axis of the Heliospheric Jets', Xiaohan Ma, Merav Opher, Marc Kornbleuth, Gabor Toth
  *American Geophysical Union (AGU) Fall Meeting 2023 San Francisco, CA, USA. 12.2023*
- 'Development of Rayleigh-Taylor-Like Driven Instability in Heliosheath with a Multi-Ion treatment', Xiaohan Ma, Merav Opher, Marc Kornbleuth, James Drake
  *American Geophysical Union (AGU) Fall Meeting 2022 Chicago, IL, USA. 12.2022*
- 'Development of Rayleigh-Taylor-Like Driven Instability in Heliosheath', Xiaohan Ma, Merav Opher, Marc Kornbleuth
  *Solar Heliospheric and Interplanetary Environment (SHINE) workshop 2022 Honolulu, HI, USA 06.2022*
- 'Electron Drift Echoes Induced by Negative Solar Wind Dynamic Pressure Impulse', Ma, X. H., Zong, Q. G., Hao, Y.X.
  *American Geophysical Union (AGU) Fall Meeting 2019 San Francisco, CA, USA. 12.2019*
- 'The Intense Substorm Incidence in Response to Interplanetary Shock: A Statistical Study', Ma, X. H., Zong, Q. G.,
  *Chinese Geoscience Union (CGU) 4th Annual Meeting Beijing, China 10.2017*
- 'The SuperMAG Indices and Inner Magnetosphere Plasma Characteristics in Response to IP Shock and Solar-wind Dynamic Pressure', Ma, X. H., Zong, Q. G.
  *Asia Oceania Geosciences Society (AOGS) 13th Annual Meeting Beijing, China 08.2016*

## HONORS & AWARDS

- NASA Earth and Space Science Fellowship 05.2021
- Dean's fellowship of Boston University 02.2020
- The award of "Outstanding scientific research" of Peking University 12.2018
- "LongRuan GIS" Scholarship of School of Earth and Space Science, Peking University (PKU) 11.2017
- Second-grade award of "Academic wishing star" of School of Earth and Space Science, PKU 05.2015
- First-grade award of " Academic wishing star" of School of Earth and Space Science, PKU 05.2014
- The award of "Merit Student" of Peking University 04.2014