Ran Ju

Tel: +86 19857136621 | Email: r.ju@zju.edu.cn
Address: International Joint Innovation Center, The Electromagnetics Academy at Zhejiang University, Zhejiang University, Haining, China, 314400

EDUCATION

Zhejiang University (ZJU) 09/2021 - 06/2024

- Master of Science, Electronic Science and Technology

Nanjing University of Posts and Telecommunications (NJUPT) 09/2017 - 06/2021

- Bachelor of Engineering (B.Eng.), Optoelectronic Information Science and Engineering
- **GPA: 4.20/5.0; Ranking: 9/269 (Top 3%)**

PROJECTS

Core-Project: Unifying dynamic and steady-state nonreciprocity in a thermal circulator 09/2021 - 07/2023

College of Information Science & Electronic Engineering of Zhejiang University, Hangzhou, China
Mentors: Prof. Hongsheng Chen (hansomchen@zju.edu.cn) and Prof. Ying Li (eleying@zju.edu.cn);

To date, most nonreciprocal effects that have been realized are for the dynamic propagation of waves. The few studies on steady-state or static nonreciprocity, where the fields are constant in time, were carried out based on totally different design principles and concepts. Therefore, it remains a mystery whether the dynamic and steady-state nonreciprocity can share any common origin, and whether it is even possible to study them in the same framework. Here, we propose a thermal circulator which breaks both the dynamic and steady-state reciprocity of heat transfer using velocity field biasing. A unified thermal scattering theory is established to analyze both cases. The dynamic nonreciprocity is attributed to an asymmetric scattering matrix. Counterintuitively, this matrix approaches a symmetric limit at steady state, but still conveys a significant steady-state nonreciprocity. Our theory reveals this unique nonreciprocal mechanism of multiple scattering, and is experimentally verified with a large isolation ratio of heat fluxes. Being the first work to report thermal nonreciprocity induced by external biasing experimentally, it is expected to inspire novel approaches for thermal energy utilization and thermal management. It could also arouse broad interests on the unification of dynamic and steady-state phenomena in acoustics, mechanics, and electromagnetics.

- Conducted literature review to learn about the classic methods used to break the reciprocity of signal transmission, and had a knowledge of the advantages as well as deficiencies of these methods.
- Constructed a wave-like theoretical framework for heat-transfer, and derived the scattering matrix for the thermal circulator.
- Calculated the strength of nonreciprocity upon our thermal scattering theory, and exploited the non-trivial dependence of nonreciprocity on several model parameters.
- Ran different calculation software, including MATLAB, MATHEMATICA, and COMSOL, to verify the consistency of results between theoretical and simulation models.
- Perfected the thermal scattering theory to address the problem where nonreciprocity seems to vanish at the zero-frequency limit; revealed the physical nature, namely the diffraction and multiple scattering, of this counterintuitive phenomenon, and reflected on the difference between thermal and acoustic systems.
- Looked up and ascertained the parameters of experimental model, then designed the platform and conducted a group of experiments successfully.
- Submitted a research paper to <*Science Advances*> as the first author (under review).

Sub-Project 1: A Review on Convective Thermal Metamaterials: Exploring High-Efficiency, Directional, and Wave-Like Heat Transfer 01/2022 – 03/2023

College of Information Science & Electronic Engineering of Zhejiang University, Hangzhou, China
Mentors: Prof. Cheng-Wei Qiu (chengwei.qiu@nus.edu.sg) and Prof. Ying Li (eleying@zju.edu.cn);

In this sub-project, we made a review on recent advancements in convective thermal metamaterials, where the state-of-the-art discoveries are classified into four sub-categories according to their functions, and a future prospect is cast on this field. In my opinion, the introduction of convection in the design of thermal metamaterials provides a new knob for controlling heat transfer beyond pure conduction, which allows active and robust thermal modulations. Besides, with the introduced convective effects, the hybrid diffusive system can be interpreted in a wave-like fashion, and revives many wave phenomena in dissipative diffusion.

- Conducted literature review to learn about the conception, development history, and the state-of-the-art advancements of this research field.
- Classified relevant research works into four sub-categories according to their functions, including enhancing heat transfer, porous-media-based thermal effects, nonreciprocal heat transfer, and non-Hermitian phenomena; Completed the paper draft.
- Discussed the finished draft with tutors to enhance my understanding of this field, which also helps me gain a deeper insight into the connection between the diffusion systems (such as thermotics and electronics) and wave systems (such as acoustics and electromagnetics) at the macro level.
- Published a review paper in <*Advanced Materials*> as the first author.

Sub-Project 2: Scalable selective absorber with quasiperiodic nanostructure for low-grade solar energy harvesting 05/2022 - 09/2022

College of Information Science & Electronic Engineering of Zhejiang University, Hangzhou, China

Mentors: Prof. Cheng-Wei Qiu (chengwei.qiu@nus.edu.sg) and Prof. Ying Li (eleying@zju.edu.cn);

In this project, we realized a flexible planar solar thermoelectric harvester that can harvest low-grade solar energy effectively under natural sunlight. With the synergy of materials properties, thermal management, and structure optimization, this device reaches a sustaining open-circuit voltage as significant as 20.

- Studied fundamental knowledge about thermoelectric effect, including Seebeck effect, Paltier effect, and Thompson effect, and familiarized with the classic works of thermal-energy harvesting.
- Ran thermoelectric examples using COMSOL, deepened the understanding of the conditions under which various thermoelectric effects are arisen.
- Established the mathematical model of heat transfer, optimized the structure of the thermoelectric chips through both analytical and numerical avenues, so that a higher harvest efficiency can be achieved.
- Published a research paper in <*APL Photonics*> as a co-author (Cover Article).

Sub-Project 3: Interdisciplinary Contest in Modeling 1/2020 - 2/2020

Mentor: Prof. Qinglun Yan (yanqinglun@njupt.edu.cn)

- Familiarized myself with a variety of data calculation, prediction, and evaluation methods, such as multiple linear regression, discriminant analysis, cluster analysis and so on.
- Ran MATLAB codes and observed the effects of different mathematic models, applied these models judiciously in solving practical problems.
- Cooperated with two teammates for 3 days to complete the modeling, programming and writing work of a research paper required by the interdisciplinary contest in modeling.
- Won the <*Meritorious Winner*> award (<10%).

PUBLICATIONS

- **R. Ju,** G. Xu, L. Xu, M. Qi, D. Wang. P.-C. Cao, R. Xi, Y. Shou, H. Chen, C.-W. Qiu and Y. Li, *Convective Thermal Metamaterials: Exploring High‐Efficiency, Directional, and Wave‐Like Heat Transfer.* Advanced Materials 35, 2209123 (2023);
- Z. Xu, Y. Li, G. Gao, F. Xie, **R. Ju**, S. Yu, K. Liu, J. Li, W. Wang, W. Li, T. Li, and C.-W. Qiu, *Scalable selective absorber with quasiperiodic nanostructure for low-grade solar energy harvesting*. APL Photonics 8.2 (2023).

HONORS AND AWARDS

Meritorious Winner, Interdisciplinary Contest in Modeling 04/2020
National scholarship, Ministry of Education of PRC **(Top 0.3%)** 12/2019
First Class Scholarship, NJUPT **(Top 3%)** 12/2019
First Class Scholarship, NJUPT **(Top 3%)** 12/2018

ADDITIONAL

Standardized Tests: TOEFL 107 (R28/L28/S23/W28)
Programming: C++, MATLAB, Mathematica
Software: COMSOL (multi-physics simulation), Rhino (3D-modeling), Origin et.al
Hobbies: Cooking