Ran Ju

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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

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. A similar concept may be extended to a broad range of heat-transfer-related problems and even other fields such as acoustics and mechanics.

- 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 <*Nature Communications*> 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	2020
Second Prize, National English Competition for College Students	2019
First Class Scholarship, NJUPT **(Top 3%)**	2018-2019
First Class Scholarship, NJUPT **(Top 3%)**	2017-2018
Best Student Model, NJUPT **(TOP 1%)**	2017-2018

ADDITIONAL

Programming: C++, MATLAB, Mathematica

Software: COMSOL (multi-physics simulation), Rhino (3D-modeling), Origin et.al

Hobbies: Jogging, Table Tennis, Cooking