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: Nonreciprocal Heat Circulation Meta-Devices 09/2021 - 05/2023

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);

Thermal nonreciprocity typically stems from nonlinearity or spatiotemporal variation of parameters. However, constrained by the inherent temperature-dependent properties and the law of mass conservation, previous works were compelled to treat dynamic and steady-state cases separately. Here, by establishing a unified thermal scattering theory, we report the creation of a convection-based thermal meta-device which supports both dynamic and steady-state nonreciprocal heat circulation. We observe the non-trivial dependence between the nonreciprocal resonance peaks and the dynamic parameters, and reveal the unique nonreciprocal mechanism of multiple scattering at steady state. This mechanism enables thermal nonreciprocity in the initially quasi-symmetric scattering matrix of our three-port meta-device, and has been experimentally validated with a significant isolation ratio of heat fluxes. Our findings establish a framework for thermal nonreciprocity that can be smoothly modulated for dynamic and steady-state heat signals, it may also offer insight into other heat-transfer-related problems or 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 <*Physical Review Letters*> 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. Hongsheng Chen (hansomchen@zju.edu.cn) 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**, P.-C. Cao, D. Wang, M. Qi, L. Xu, S. Yang, C.-W. Qiu, H. Chen and Y. Li, *Bridging dynamic and steady-state nonreciprocity in a thermal circulator.* Physical Review Letters (under review)
- **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
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