

# Shuai (S. A.) Yuan

Ph.D. Candidate (Expected graduation date: Jun 2024)

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## EDUCATION

**Zhejiang University (ZJU),**

Hangzhou, China

*Ph. D. candidate, supervised by Prof. Wei E. I. Sha (<http://www.zjuisee.zju.edu.cn/weishal/>)*

Sep 2019 - Present

**University of Trento (UniTN),**

Trento, Italy

*Visiting Ph. D. student, supervised by Prof. Andrea Massa*

Mar 2023 - Mar 2024

**Institut supérieur d'électronique de Paris (ISEP),**

Paris, France

*Visiting undergraduate student, project supervised by Prof. Maria Trocan*

Sep 2017 - Feb 2018

**Nanjing University of Aeronautics and Astronautics (NUAA),**

Nanjing, China

*B. E. in electronic science and technology, GPA top 10%*

Sep 2015 - Jul 2019

## INTERESTS

My research interests are in electromagnetic information theory and relevant wave engineering designs. Specifically, I am interested in the electromagnetic analytical and numerical methods that benefit the modeling of wireless communications. Additionally, I am keen on exploring novel hardware designs by leveraging the physical insights of communication systems. In the context of emerging scenarios and applications in 6G communications, it is essential to clarify the electromagnetic implications of information and model systems from an electromagnetic perspective. Addressing these new challenges often requires combining multiple research areas, including wave physics, antenna design, channel modeling, circuit design, etc. I have worked on several relevant projects, some of the codes can be found on my GitHub page: <https://github.com/Shuai-Yuan-1997>.

## RESEARCH EXPERIENCE

### • Electromagnetic information theory

Using computational electromagnetic methods to model and characterize wireless communication systems, including the free-space dyadic Green's function for near-field MIMO communications [2], volume integral equation method for inhomogeneous environments [4] and programmable environments [ongoing], T-matrix method for communication environments with multiple compact scatterers [6], angular spectrum analysis for deducing the degree-of-freedom limit of MIMO systems [3].

### • Characterizing the MIMO performance of practical antenna arrays

Characterizing the MIMO performance (i.e., capacity, degree of freedom) of practical antenna arrays based on channel models in different environments, including the Clarke and Kronecker models for Rayleigh channel [1, 11], and the 3GPP models (QuaDRiGa) for spatial correlation channels [1]. For 6G communications, it is necessary to simultaneously consider the antenna radiation pattern, antenna efficiency, scattering environment (especially angular spread), beamforming/precoding methods in the design process of MIMO antenna arrays.

### • Design and optimization of antennas/metasurfaces

Designing and optimizing the antennas/metasurfaces for different applications, including the design of a Pancharatnam-Berry metasurface for optimal OAM multiplexing [3], the design of a miniaturized frequency-selective surface absorber based on 2.5-D knitted structure [7], the design of an EBG based 3-D antenna array for breaking the degree-of-freedom limit of MIMO systems built with planar arrays [1]. Familiar with the relevant numerical methods, full-wave simulations, fabrications, and measurements.

## SKILLS

- **Software:** CST, CST-MATLAB/Python Co-simulation, HFSS, COMSOL, QuaDRiGa (3GPP Simulation)
- **Experiments:** Microwave measurements of antennas and metasurfaces in anechoic chamber
- **Programming:** MATLAB, Python, C
- **Languages:** English (Fluent), Mandarin (Native), IELTS 7.0 (R8.5/L7.5/W5.5/S7.0), GRE V:149 Q:167AW: 3.0

## PUBLICATIONS

- [1] **S. S. A. Yuan**, J. Wu, H. Xu, T., D. Li, X. Chen, C. Huang, S. Sun, S. Zheng, X. Zhang, E.-P. Li, and W. E. I. Sha, "Breaking the degrees-of-freedom limit of holographic MIMO communications: A 3-D antenna array topology," *IEEE Trans. Veh. Technol.*, accepted, doi: 10.1109/TVT.2024.3372704. (arxiv.org/abs/2311.03004)
- [2] **S. S. A. Yuan**, Z. He, X. Chen, C. Huang and W. E. I. Sha, "Electromagnetic effective degree of freedom of an MIMO system in free space," *IEEE Antennas Wirel. Propag. Lett.*, vol. 21, no. 3, pp. 446-450, March 2022. (48 citations)
- [3] **S. S. A. Yuan**, J. Wu, M. L.N. Chen, Z. Lan, L. Zhang, S. Sun, Z. Huang, X. Chen, S. Zheng, L. J. Jiang, X. Zhang, and W. E. I. Sha, "Approaching the fundamental limit of orbital-angular-momentum multiplexing through a hologram metasurface," *Phys. Rev. Applied*, vol. 16, pp. 064042, Dec. 2021.
- [4] **S. S. A. Yuan**, Z. He, S. Sun, X. Chen, C. Huang, and Wei E. I. Sha, "Electromagnetic effective-degree-of-freedom limit of a MIMO system in 2-D inhomogeneous environment," *Electronics*. (Featured paper in Special Issue: Recent Advancements and Applications of Computational Electromagnetics)
- [5] **S. S. A. Yuan**, X. Chen, C. Huang and W. E. I. Sha, "Effects of mutual coupling on degree of freedom and antenna efficiency in holographic MIMO communications," *IEEE Open J. Antennas Propag.*, vol. 4, pp. 237-244, 2023.
- [6] **S. S. A. Yuan**, Z. H. Lin, L. -B. Lv, S. -J. Hao and W. E. I. Sha, "Investigating the scattering characteristics of artificial field-aligned irregularities based on T-matrix algorithm," *IEEE J. Multiscale Multiphys. Comput. Tech.*, vol. 8, pp. 147-157, 2023.
- [7] **S. Yuan**, X. K. Kong, Q. M. Yu, S. B. Liu, "Miniaturization of frequency-selective absorber based on 2.5-D knitted structure," Wiley Online Library, *Int. J. RF Microw. Comput.-Aided Eng.*, vol. 30, no.2, pp. e22066, Nov. 2019.
- [8] Y. Shen, Z. He, W. E. I. Sha, **S. S. A. Yuan** and X. Chen, "Electromagnetic effective-degree-of-freedom prediction with parabolic equation method," *IEEE Trans. Antennas Propag.*, vol. 71, no. 4, pp. 3752-3757, April 2023.
- [9] Z. H. Lin, **S. S. A. Yuan** and K. Li, "Radiation field inside the homogeneous moon excited by a vertical magnetic dipole," *IEEE Access*, doi: 10.1109/ACCESS.2022.3147351.
- [10] **S. S. A. Yuan** and W. E. I. Sha, "Breaking the degree-of-freedom limit of aperture-constrained MIMO communication systems by 3-D antenna arrays," 2023 IEEE International Symposium on Antennas and Propagation and USNC-URSI Radio Science Meeting (USNC-URSI), Portland, OR, USA, 2023, pp. 1045-1046.
- [11] **S. S. A. Yuan** and W. E. I. Sha, "Limit of an aperture-fixed MIMO system considering the Chu limit of antenna," 2022 IEEE International Symposium on Antennas and Propagation and USNC-URSI Radio Science Meeting (AP-S/URSI), Denver, CO, USA, 2022, pp. 1980-1981.
- [12] **S. S. A. Yuan** and W. E. I. Sha, "Electromagnetic degree of freedom of a MIMO communication system," 2022 IEEE 5th International Conference on Electronic Information and Communication Technology (ICEICT), Hefei, China, 2022, pp. 667-669.

## TEACHING

**Teaching Assistant: Lecture on Fundamental of Optoelectronics (in English)**

*Undergraduate level course on Electromagnetics, Wave Physics, and Optics*

Zhejiang University

Mar - June, 2020-2023

## SERVICES

- Reviewer for *IEEE Trans. Antennas Propag.*, *IEEE Antennas Wirel. Propag. Lett.*, *IEEE Antennas Propag. Mag.*, *Signal Processing*
- Secretary of *IEEE Nanjing Section Zhejiang Chapter*

## REFERENCES

Wei E. I. Sha ([weisha@zju.edu.cn](mailto:weisha@zju.edu.cn), [google scholar](#))

Chongwen Huang ([chongwenhuang@zju.edu.cn](mailto:chongwenhuang@zju.edu.cn), [google scholar](#))

Xiaoming Chen ([xiaoming.chen@mail.xjtu.edu.cn](mailto:xiaoming.chen@mail.xjtu.edu.cn), [google scholar](#))

Andrea Massa ([andrea.massa@unitn.it](mailto:andrea.massa@unitn.it), [google scholar](#))

Associate Professor, Zhejiang University

Associate Professor, Zhejiang University

Professor, Xi'an Jiaotong University

Professor, University of Trento