

Shuai (S. A.) Yuan

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

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EDUCATION

Zhejiang University (ZJU),

Ph. D. candidate, supervised by Prof. Wei E. I. Sha

Hangzhou, China

Sep 2019 - Present

University of Trento (UniTN),

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

Trento, Italy

Mar 2023 - Mar 2024

Institut supérieur d'électronique de Paris (ISEP),

Visiting undergraduate student, supervised by Prof. Maria Trocan

Paris, France

Sep 2017 - Feb 2018

Nanjing University of Aeronautics and Astronautics (NUAA),

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

Nanjing, China

Sep 2015 - Jul 2019

INTERESTS

My research interests are in electromagnetic information theory and relevant hardware designs. More specifically, I am interested in electromagnetic analytical and numerical methods that benefit the modeling of wireless communications, as well as exploring novel hardware designs by exploiting the physical insights of communication systems. For new scenarios and applications in 6G communications, the electromagnetic connotations of information are necessary to be made clear, and many research areas should be combined for tackling the new challenges, such as 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:*

RESEARCH EXPERIENCE

• Electromagnetic information theory

Using computational electromagnetic methods for the modeling and characterization of wireless communication systems, including the free-space dyadic Green's function method for near-field communications [2], volume integral equation method for inhomogeneous environments [4] and smart electromagnetic environments [in progress], T-matrix method for environments with multiple regular compact scatterers [6], angular spectrum analysis for deducing the degree-of-freedom limit of MIMO systems [3])

• MIMO performance characterization of antenna arrays in different environments

Characterizing the MIMO performance (i.e., capacity, degree of freedom) of antenna arrays based on channel models for different environments, including the Clarke and Kronecker models for Rayleigh channel [1, 11], 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 for the evaluation and design 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], design of an electromagnetic band-gap structure based 3-D antenna array for breaking the degree-of-freedom limit of planar array [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. (45 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 rasorber 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 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	Associate Professor, Zhejiang University
Xiaoming Chen	Professor, Xi'an Jiaotong University
Chongwen Huang	Associate Professor, Zhejiang University
Andrea Massa	Professor, University of Trento