GUANGJIN MOU

Mechanical Metamaterials: Exotic Anisotropy & Inverse Design

China | 12 October 1995
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RESEARCH PROFILE

I study how anisotropic materials can exhibit **selected elastic responses of higher symmetry**, and use the associated constitutive constraints to design mechanical metamaterials. My approach combines **group theory applied to the space of linear constitutive laws, topology optimization and experimental validation** to identify and realize exotic anisotropy. Planned extensions address elastic wave propagation and phononics for on-chip acoustic signal processing in communication devices.

EXPERIENCE

Postdoctoral Researcher / Exotic Metamaterial Design

The Hong Kong University of Science and Technology

2025.09 – present | Hong Kong, China

Advisor: Tianju Xue

- **Developed 3D exotic elasticity theory.** Extended the theory of exotic anisotropy developed during my PhD from 2D to 3D linear elasticity, identifying 18 exotic constitutive structures in symmetry classes higher than orthotropy [3].
- **Developed a 3D inverse design framework.** Formulated inverse design against prescribed effective stiffness tensors using level-set methods and topological derivatives, with MPI-based parallel computing and GPU acceleration for the numerical optimization [4].
- **Validated exotic behavior experimentally.** Proposed an experimental approach to validate isotropic deviatoric elasticity in planar metamaterials through a single tensile test on a 3D-printed specimen, combining full-field measurements with the Virtual Fields Method [2].

Postdoctoral Researcher / Hygromorphic Materials

Arts et Métiers, PIMM Laboratory

2024.03 – 2025.06 | Paris, France

Advisors: Justin Dirrenberger, Antoine Le Duigou

- Modelled geometrically nonlinear multiphysics coupling in heterogeneous multilayers, predicting humidity-driven bending and sequential deformation of pine-cone scales for bioinspired adaptive structure design.

Doctoral Researcher / Theory of Exotic Anisotropy

Sorbonne University, Institut Jean le Rond d'Alembert

2020.10 – 2024.02 | Paris, France

Supervisors: Nicolas Auffray, Boris Desmorat

- **Established exotic anisotropy theory.** Applied group theory and geometric analysis to the space of linear constitutive laws to establish mathematical and mechanical definitions of exotic anisotropy, for which the selected elastic responses exhibit higher symmetry than the underlying constitutive law [1].
- **Designed exotic metamaterials.** Identified R_0-orthotropy as the unique exotic anisotropy in 2D linear elasticity and designed corresponding periodic unit cells.

Research Intern / Constitutive Identification

Safran / LEM3 Laboratory

2020.01 – 2020.06 | Metz, France

Identified constitutive parameters of additively manufactured AlSi–PE abradable materials for aero-engine casings using Brazilian (diametral compression) tests.

EDUCATION

PhD / Mechanics of Materials

Sorbonne University

2020.10 – 2024.02 | Paris, France

ANR MAX-OASIS funded PhD; SMAER Doctoral School.

Master's Degree / Materials Science

École Nationale d'Ingénieurs de Metz (ENIM)

2017.09 – 2020.07 | Metz, France

Bachelor's / Aircraft Propulsion Engineering

Nanjing University of Aeronautics and Astronautics (NUAA)

2014.09 – 2017.07 | Nanjing, China

TEACHING & SUPERVISION

Undergraduate tutorials

- Statics, HKUST: Fall 2025, 36 h.
- Thermodynamics, Sorbonne: Fall 2022, 32 h.

Co-supervision of doctoral research

- Acoustic metamaterials: design and validation (2026).
- 3D printing; constitutive tests via virtual work (2025).

HONORS & AWARDS

- Outstanding Graduate, ESCP Entrepreneurship Program (2023).
- First Prize, "Chunhui Cup": Intelligent Construction and AI Innovation and Entrepreneurship Competition, France (2022).
- President's Special Commendation, NUAA (2017).
- First-Class University Scholarship, NUAA (2015–2017).
- Organization Department Head, NUAA University Youth League Committee (2016–2017).

FUTURE RESEARCH

- **Exotic wave-propagation theory.** Apply exotic anisotropy theory to second-gradient constitutive law spaces to predict and control elastic wave propagation.
- **On-chip acoustic signal processing.** Combine inverse design and micro/nanofabrication for phononic control in communication devices.

PATENT

Decoupled transversely isotropic metamaterial unit cell with shape-preserving volumetric deformation under hydrostatic pressure and a topology design method

U.S. provisional application; pending

U.S. provisional patent application No. 64/145600, filed 9 January 2026.

PUBLICATIONS

[1] **Mou, G.**, Desmorat, B., Turlin, R., Auffray, N. (2023). On exotic linear materials: 2D elasticity and beyond. *International Journal of Solids and Structures*, 264, 112103.
First and corresponding author. Established the definition and classification of exotic anisotropy, including the 2D linear elastic case and a periodic unit-cell realization.

[2] **Mou, G.**, Dong, D., Chen, J., Zhang, S., Liu, S., Lu, Y., Auffray, N., Xue, T. (2026). A planar orthotropic mechanical metamaterial with isotropic deviatoric elasticity. *International Journal of Mechanical Sciences*, 325, 111832.
First author. Validated isotropic deviatoric elasticity in an orthotropic material through specimen fabrication and experimental constitutive identification.

[3] Auffray, N., **Mou, G.**, Desmorat, B. (2026). On Exotic Materials in 3D Linear Elasticity with High Symmetry Classes. *Proceedings of the Royal Society A*. **In press.**
Corresponding author. Extended the theory to 3D and identified 18 exotic constitutive structures in symmetry classes higher than orthotropy.

[4] **Mou, G.**, Auffray, N., Ye, Y., Xue, T. (2026). A level-set topological derivative framework for multiscale linear elasticity and the design of 3D exotic materials. *Computer Methods in Applied Mechanics and Engineering*. **Under review.**
First author. Developed a unified optimization framework targeting prescribed stiffness matrices for 3D metamaterial microstructure design.

[5] **Mou, G.**, Desmorat, B., Turlin, R., Auffray, N. (2022). Conception de matériaux architecturés exotiques en élasticité 2D. *25th French Congress of Mechanics (CFM)*, Nantes, France.
First author; conference paper.

Collaborative Publications

- Xu, W., Xie, Z., Lin, H., Wang, X., **Mou, G.**, Xue, T. (2026). Style-Constrained Inverse Design of Microstructures With Tailored Mechanical Properties Using Unconditional Diffusion Models. *International Journal for Numerical Methods in Engineering*, 127(13), e70376.
- Zhang, Y., Zhai, C., Li, Z., Li, J., **Mou, G.**, Chen, L., et al. (2026). Nonreciprocal transition waves in active lattices. *Journal of the Mechanics and Physics of Solids*, 215, 106697.

CONFERENCE CONTRIBUTIONS

- **ICCES 2026, Hong Kong**: Design and experimental validation of R_0-orthotropic metamaterials (2026.08).
- **FEniCS Conference 2026, Paris**: An integrated large language model (LLM)–FEniCS platform for computational mechanics; software demonstration (2026.06).
- **CMCS 2025, France**: Predicting sequential hygromorphic deformation of pine-cone scales for bioinspired design; poster (2025.05).
- **CFM 2022, France**: Design of exotic anisotropic architectured materials.
- **Coss&Vita Joint Workshop, Italy**: Definition and potential applications of exotic anisotropic materials in 2D elasticity (2022.05).