

# Zhenyu Liao

## Curriculum Vitae

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📄 Male, Chinese, born in 28/08/1992.

### Education

- 2019 **Ph.D.** Statistics and Machine Learning [L2S, CentraleSupélec, University of Paris-Saclay](#), France.
- 2016 **M.Sc.** Signal and Image Processing [University of Paris-Saclay](#), France.
- 2014 **B.Sc.** Optical & Electronic Information [Huazhong university of Science and Technology](#), China.

### Experiences

- 2021-now: **Research Associated Professor** at [School of Electronic Information and Communications, Huazhong University of Science and Technology \(HUST\)](#).
- 2020-2021: **Postdoctoral Scholar** at [ICSI](#) and [Department of Statistics, University of California, Berkeley](#), hosted by Prof. [Michael Mahoney](#).

### Honor and Awards

- 2021: Recipient of the 2021 Wuhan Youth Talent, Wuhan, China.
- 2021: Recipient of East Lake Youth Talent Program Fellowship of HUST, Wuhan, China.
- 2019: 2nd prize of ED STIC Ph.D. Student Award of University Paris-Saclay, France.
- 2016: Recipient of the Supélec Foundation Ph.D. Fellowship, France.

### Research Grants

- 2023-2025: **PI**, National Natural Science Foundation of China, youth program “*Fundamental Limits of Pruning Deep Neural Network Models via Random Matrix Methods*” (NSFC-62206101), ¥300K.
- 2022-2024: **contributor**, National Natural Science Foundation of China, grants for “*Mathematical Foundations for Future Communications (Information Theory)*” (NSFC-12141107), ¥3M. PI: Robert C. Qiu.
- 2021-2022: **PI**, CCF-Hikvision Open Fund, *Random Matrix Theory and Information Bottleneck for Neural Network Compression* (20210008), ¥280K.
- 2021-2023: **PI**, Fundamental Research Funds for the Central Universities of China, *Large Dimensional Random Matrix Methods in Machine Learning: Theory and Practice* (No. 2021XXJS110), ¥500K.
- 2021-2023: **contributor**, Key Research and Development Program of Hubei Province, *Research on Key Technologies of Next-generation Industrial Internet Network* (2021BAA037), ¥1 000K., PI: Daiming Qu.
- 2018-2021: **contributor**, NSF Research Grant, *Combining Stochastics and Numerics for Improved Scalable Matrix Computations* (NSF-1815054), \$500K, PI: Michael W. Mahoney.
- 2018-2021: **contributor**, Programme d’Investissements d’avenir, *GSTATS IDEX DataScience Chair*, University of Grenoble-Alpes, €300K, PI: Romain Couillet.
- 2014-2017, **contributor**, French National Research Agency, *Random Matrix Theory for Large Dimensional Graphs* (ANR-14-CE28-0006), €300K, PI: Romain Couillet.

### Organization of Scientific Activities

- 2022 Joint workshop on “[Math for Data Science](#)” between [HUST](#) and [University of Paris-Saclay](#), with more than 40 000 online attendees, see [playback](#).
- 1st Workshop in High-dimensional Learning Dynamics ([HiLD](#)) at [ICML 2023](#), Honolulu, Hawaii.

## Publications

### Books

1. Romain Couillet and **Zhenyu Liao**. *Random Matrix Methods for Machine Learning*. Cambridge University Press, 2022. DOI: [10.1017/9781009128490](https://doi.org/10.1017/9781009128490).

### Papers in conference proceedings

1. Lingyu Gu, Yongqi Du, Yuan Zhang, Di Xie, Shiliang Pu, Robert Qiu, and Zhenyu Liao. “Lossless” Compression of Deep Neural Networks: A High-dimensional Neural Tangent Kernel Approach. In: *Advances in Neural Information Processing Systems*. Vol. 35. Curran Associates, Inc., 2022, pp.3774–3787. [https://proceedings.neurips.cc/paper\\_files/paper/2022/file/185087ea328b4f03ea8fd0c8aa96f747-Paper-Conference.pdf](https://proceedings.neurips.cc/paper_files/paper/2022/file/185087ea328b4f03ea8fd0c8aa96f747-Paper-Conference.pdf).

2. Hafiz Tiomoko Ali, **Zhenyu Liao**, and Romain Couillet. Random matrices in service of ML footprint: ternary random features with no performance loss. In: *International Conference on Learning Representations (ICLR)*. 2022. <https://openreview.net/forum?id=qwULHx9zld>.
3. **Zhenyu Liao** and Michael W Mahoney. Hessian Eigenspectra of More Realistic Nonlinear Models. In: *Advances in Neural Information Processing Systems (NeurIPS)*. Vol. 34. Curran Associates, Inc., 2021, pp.20104–20117. <https://papers.nips.cc/paper/2021/hash/a7d8ae4569120b5bec12e7b6e9648b86-Abstract.html>.
4. Michal Dereziński, **Zhenyu Liao**, Edgar Dobriban, and Michael Mahoney. Sparse sketches with small inversion bias. In: *Proceedings of Thirty Fourth Conference on Learning Theory (COLT)*. Vol. 134. PMLR, Aug. 2021, pp.1467–1510. <https://proceedings.mlr.press/v134/dereziński21a.html>.
5. **Zhenyu Liao**, Romain Couillet, and Michael W. Mahoney. Sparse Quantized Spectral Clustering. In: *International Conference on Learning Representations (ICLR)*. 2021. <https://openreview.net/forum?id=pBqLS-7KYAF>.
6. Fanghui Liu, **Zhenyu Liao**, and Johan Suykens. Kernel Regression in High Dimension: Refined Analysis beyond Double Descent. In: *Proceedings of The 24th International Conference on Artificial Intelligence and Statistics (AISTATS)*. Vol. 130. PMLR, Apr. 2021, pp.649–657. <http://proceedings.mlr.press/v130/liu21b.html>.
7. **Zhenyu Liao**, Romain Couillet, and Michael W. Mahoney. A Random Matrix Analysis of Random Fourier Features: Beyond the Gaussian Kernel, A Precise Phase Transition, and the Corresponding Double Descent. In: *Advances in Neural Information Processing Systems (NeurIPS)*. Vol. 33. Curran Associates, Inc., 2020, pp.13939–13950. <https://papers.nips.cc/paper/2020/hash/a03fa30821986dff10fc66647c84c9c3-Abstract.html>.
8. Michal Dereziński, Feynman T Liang, **Zhenyu Liao**, and Michael W. Mahoney. Precise expressions for random projections: Low-rank approximation and randomized Newton. In: *Advances in Neural Information Processing Systems (NeurIPS)*. Vol. 33. Curran Associates, Inc., 2020, pp.18272–18283. <https://papers.nips.cc/paper/2020/hash/d40d35b3063c11244fbf38e9b55074be-Abstract.html>.
9. **Zhenyu Liao** and Romain Couillet. On Inner-Product Kernels of High Dimensional Data. In: *2019 IEEE 8th International Workshop on Computational Advances in Multi-Sensor Adaptive Processing (CAMSAP)*. IEEE. 2019, pp.579–583. doi: [10.1109/CAMSAP45676.2019.9022455](https://doi.org/10.1109/CAMSAP45676.2019.9022455).
10. Xiaoyi Mai, **Zhenyu Liao**, and Romain Couillet. A Large Scale Analysis of Logistic Regression: Asymptotic Performance and New Insights. In: *IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP)*. IEEE. May 2019, pp.3357–3361. doi: [10.1109/ICASSP.2019.8683376](https://doi.org/10.1109/ICASSP.2019.8683376).
11. Romain Couillet, **Zhenyu Liao**, and Xiaoyi Mai. Classification Asymptotics in the Random Matrix Regime. In: *The 26th European Signal Processing Conference (EUSIPCO)*. IEEE. Sept. 2018, pp.1875–1879. doi: [10.23919/EUSIPCO.2018.8553034](https://doi.org/10.23919/EUSIPCO.2018.8553034).
12. **Zhenyu Liao** and Romain Couillet. The Dynamics of Learning: A Random Matrix Approach. In: *Proceedings of the 35th International Conference on Machine Learning (ICML)*. Vol. 80. PMLR, July 2018, pp.3072–3081. <http://proceedings.mlr.press/v80/liao18b.html>.
13. **Zhenyu Liao** and Romain Couillet. On the Spectrum of Random Features Maps of High Dimensional Data. In: *Proceedings of the 35th International Conference on Machine Learning (ICML)*. Vol. 80. PMLR, July 2018, pp.3063–3071. <http://proceedings.mlr.press/v80/liao18a.html>.
14. **Zhenyu Liao** and Romain Couillet. Random Matrices Meet Machine Learning: A Large Dimensional Analysis of LS-SVM. In: *IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP)*. IEEE. Mar. 2017, pp.2397–2401. doi: [10.1109/ICASSP.2017.7952586](https://doi.org/10.1109/ICASSP.2017.7952586).

## Journal papers

1. Yacine Chitour, **Zhenyu Liao**, and Romain Couillet. A geometric approach of gradient descent algorithms in linear neural networks. *Mathematical Control and Related Fields* **13**(3) (2023), 918–945. doi: [10.3934/mcrf.2022021](https://doi.org/10.3934/mcrf.2022021).
2. **Zhenyu Liao**, Romain Couillet, and Michael W Mahoney. A random matrix analysis of random Fourier features: beyond the Gaussian kernel, a precise phase transition, and the corresponding double descent. *Journal of Statistical Mechanics: Theory and Experiment* **2021**(12) (Dec. 2021), 124006. doi: [10.1088/1742-5468/ac3a77](https://doi.org/10.1088/1742-5468/ac3a77).
3. **Zhenyu Liao** and Romain Couillet. A Large Dimensional Analysis of Least Squares Support Vector Machines. *IEEE Transactions on Signal Processing* **67**(4) (Feb. 2019), 1065–1074. doi: [10.1109/TSP.2018.2889954](https://doi.org/10.1109/TSP.2018.2889954).

4. Cosme Louart, **Zhenyu Liao**, and Romain Couillet. A Random Matrix Approach to Neural Networks. *The Annals of Applied Probability* 28(2) (Apr. 2018), 1190–1248. doi: [10.1214/17-AAP1328](#).

## Peer Reviewing

- Referee of [European Research Council \(ERC\)](#).
- External reviewer of [Natural Sciences and Engineering Research Council of Canada \(NSERC\)](#).
- Referee of [National Natural Science Foundation of China \(NSFC\)](#).
- Conferences: [NeurIPS](#), [ICML](#), [ICLR](#), [AISTATS](#), [AAAI](#), [ECAI](#), [ICC](#), [CAMSAP](#).
- Journals: [Journal of Machine Learning Research \(JMLR\)](#), [IEEE Trans. on Pattern Analysis and Machine Intelligence \(IEEE-TPAMI\)](#), [IEEE Trans. on Signal Processing \(IEEE-TSP\)](#), [IEEE Trans. on Neural Networks and Learning Systems \(IEEE-TNNLS\)](#), [Transactions on Machine Learning Research \(TMLR\)](#), [Springer Statistics and Computing \(STCO\)](#), [SIAM Journal on Scientific Computing \(SISC\)](#), [Pattern Recognition \(PR\)](#), [Random Matrices: Theory and Applications \(RMTA\)](#), [Latin American Journal of Probability and Mathematical Statistics \(ALEA\)](#), [Foundations of Computational Mathematics \(FoCM\)](#), [Neural Processing Letters \(NPL\)](#), [PLOS ONE](#).

## Tutorials and Invited Talks

- Invited talk on “[Random Matrix Methods for Machine Learning: “Lossless” Compression of Large and Deep Neural Networks](#)”, SPMS MAS Seminar Series, School of Physical and Mathematical Sciences, Nanyang Technological University, Jan, 2023.
- Invited talk on “[Random Matrix Methods for Machine Learning: An Application to “Lossless” Compression of Large and Deep Neural Networks](#)”, SDS Workshop on “Topics in Random Matrix Theory”, CUHK-Shenzhen, October, 2022.
- Invited talk on “[Random Matrix Methods for Machine Learning: “Lossless” Compression of Large Neural Networks](#)”, Institute for Interdisciplinary Information Sciences (IIIS), Tsinghua University, August, 2022.
- Invited talk on “Random Matrix Methods for Machine Learning: “Lossless” Compression of Large Neural Networks”, [China conference on Scientific Machine Learning \(CSML 2022\)](#), August, 2022.
- Invited talk on “[Random Matrix Methods for Machine Learning](#)”, Gaoling School of Artificial Intelligence, Renmin University of China, March, 2022.
- Invited talk on “Performance-complexity Trade-off in Large Dimensional Spectral Clustering”, [HUST Vision and Learning Salon 2021](#), Huazhong University of Science and Technology, December, 2021.
- Invited talk on “A Random Matrix Approach to Large Dimensional Machine Learning”, [AI+Math Colloquia](#), Institute of Natural Sciences, Shanghai Jiao Tong University, 2021.
- Invited talk on “A Random Matrix Approach to Large Dimensional Machine Learning”, [STAT-DS Seminar](#), Department of Statistics and Data Science, Southern University of Science and Technology, 2021.
- Invited talk on “A Random Matrix Approach to Large Dimensional Machine Learning”, [Optimization Seminar, Academy of Mathematics and Systems Science](#), Chinese Academy of Science, 2021.
- Invited talk on “A Data-dependent Theory of Overparameterization: Phase Transition, Double Descent, and Beyond” at [Workshop on the Theory of Over-parameterized Machine Learning \(TOPML\) 2021](#). April 20-21, 2021. Link to [video](#).
- Invited talk on “Performance-complexity Trade-off in Large Dimensional Spectral Clustering”, [Statistics Seminar](#), Research School of Finance, Actuarial Studies and Statistics, Australian National University, Canberra, 2021.
- Invited talk on “Performance-complexity Trade-off in Large Dimensional Spectral Clustering”, HUAWEI First Mini-workshop on Random Matrix Theory and Machine Learning, Paris, 2021.
- Invited talk on “Performance-complexity Trade-off in Large Dimensional Spectral Clustering”, [STA 290 Seminar](#), Department of Statistics, University of California, Davis, 2021.
- Invited talk on “Dynamical Aspects of Learning Linear Neural Networks”, The Fields Institute for Research in Mathematical Sciences, [Second Symposium on Machine Learning and Dynamical Systems](#), 2020. Link to [video](#).
- Invited talk on “Random Matrix Advances in Large Dimensional Machine Learning”, Shanghai University of Finance and Economics, [Random Matrices and Complex Data Analysis Workshop](#), Shanghai, 2019.
- Invited talk on “Random Matrix Viewpoint of Learning with Gradient Descent”, [DIMACS, Workshop on Randomized Numerical Linear Algebra, Statistics, and Optimization](#), Rutgers University, 2019. Link to [video](#).
- Invited talk on “Recent Advances in Random Matrix Theory for Machine Learning and Neural Nets”, workshop of the [Matrix](#) series on “*Random matrix theory faces information era*”, Kraków, Poland, 2019. Link to [video](#).

- Invited talk on “Dynamical Aspects of Deep Learning” (with Y. Chitour), *Séminaire d'Automatique du plateau de Saclay of iCODE institute*, Paris, France, 2019.
- Invited talk on “Recent Advances in Random Matrix for Neural Networks”, *Workshop on deep learning theory*, Shanghai JiaoTong University, China, 2018.
- **Tutorial** on “Random Matrix Advances in Machine Learning and Neural Nets” (with R. Couillet and X. Mai), *The 26th European Signal Processing Conference (EUSIPCO'18)*, Roma, Italy, 2018.

## References

- **Prof. Romain Couillet**
  - Full Professor at University Grenoble-Alps, France
  - Holder of the UGA MIAI LargeDATA Chair, University-Grenoble-Alps, France.
  - ✉ [romain.couillet@gipsa-lab.grenoble-inp.fr](mailto:romain.couillet@gipsa-lab.grenoble-inp.fr)
- **Prof. Yacine Chitour**
  - Full Professor at Pairs-Sud, University Paris-Saclay, France.
  - Director of the H-CODE institute, University Paris-Saclay, France.
  - ✉ [yacine.chitour@l2s.centralesupelec.fr](mailto:yacine.chitour@l2s.centralesupelec.fr)
- **Prof. Michael W. Mahoney**
  - Associate Adjunct Professor at Department of Statistics, UC Berkeley, CA, USA.
  - Director of the UC Berkeley FODA (Foundations of Data Analysis) Institute, Berkeley, CA, USA.
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