

# Shuyang Gong

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## Research Interests

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My research interest is probability theory, and its applications into statistics, statistical physics and theoretical computer science.

## Education

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**School of Mathematical Sciences, Peking University**, Beijing, China September, 2021 — June, 2026(expected)  
PhD in Probability and Statistics

**The Fuqua School of Business, Duke University**, Durham, United States September, 2024 — January, 2025  
Visiting PhD student, host: Jiaming Xu

**Department of Mathematics, Shandong University**, Jinan, China September, 2017 — June, 2021  
Bachelor in Statistics (with honor): GPA ranked 1st/132

## Academic Experience

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**Simons Laufer Mathematical Sciences Institute(MSRI)** Berkeley, United States  
*Program Associate* January, 2025 — February, 2025  
**The 2024 CRM-PIMS summer school** Montréal, Canada  
*Visiting Student* July, 2024

## Publications

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- **A Proof of The Changepoint Detection Threshold Conjecture in Preferential Attachment Models**

*Preprint:* <https://arxiv.org/abs/2502.00514>, *submitted*

Coauthor: Hang Du and Jiaming Xu

**Abstract:** We investigate the problem of detecting and estimating a changepoint in the attachment function of a network evolving according to a preferential attachment model on  $n$  vertices, using only a single final snapshot of the network. Bet et al. show that a simple test based on thresholding the number of vertices with minimum degrees can detect the changepoint when the change occurs at time  $n - \Omega(\sqrt{n})$ . They further make the striking conjecture that detection becomes impossible for any test if the change occurs at time  $n - o(\sqrt{n})$ . Kaddouri et al. make a step forward by proving the detection is impossible if the change occurs at time  $n - o(n^{1/3})$ . In this paper, we resolve the conjecture affirmatively, proving that detection is indeed impossible if the change occurs at time  $n - o(\sqrt{n})$ . Furthermore, we establish that estimating the changepoint with an error smaller than  $o(\sqrt{n})$  is also impossible, thereby confirming that the estimator proposed in Bhamidi et al. is order-optimal.

- **A computational transition for detecting correlated stochastic block models by low-degree polynomials**

*Preprint:* <https://arxiv.org/abs/2409.00966>, *submitted*

Coauthor: Guanyi Chen, Jian Ding and Zhangsong Li

**Abstract:** Detection in a pair of random graphs is a fundamental statistical and computational problem that has been extensively studied in recent years. In this work, we consider a pair of correlated (sparse) stochastic block models  $\mathcal{S}(n, \frac{\lambda}{n}; k, \epsilon; s)$  that are subsampled from a common parent stochastic block model  $\mathcal{S}(n, \frac{\lambda}{n}; k, \epsilon)$  with  $k = O(1)$  symmetric communities, average degree  $\lambda = O(1)$ , divergence parameter  $\epsilon$ , and subsampling probability  $s$ .

For the detection problem of distinguishing this model from a pair of independent Erdős-Rényi graphs with the same edge density  $\mathcal{G}(n, \frac{\lambda s}{n})$ , we focus on tests based on *low-degree polynomials* of the entries of the adjacency matrices, and we determine the threshold that separates the easy and hard regimes. More precisely, we show that this class of tests can distinguish these two models if and only if  $s > \min\{\sqrt{\alpha}, \frac{1}{\lambda\epsilon^2}\}$ , where  $\alpha \approx 0.338$  is the Otter's constant and  $\frac{1}{\lambda\epsilon^2}$  is the Kesten-Stigum threshold. Our proof of low-degree hardness is based on a conditional variant of the low-degree likelihood calculation.

- **The Umeyama algorithm for matching correlated Gaussian geometric models in the low-dimensional regime.**

*Preprint:* <https://arxiv.org/abs/2402.15095>, *submitted*

Coauthor: Zhangsong Li

**Abstract:** Motivated by the problem of matching two correlated random geometric graphs, we study the problem of matching two Gaussian geometric models correlated through a latent node permutation. Specifically, given an unknown permutation  $\pi^*$  on  $\{1, \dots, n\}$  and given  $n$  i.i.d. pairs of correlated Gaussian vectors  $\{X_{\pi^*(i)}, Y_i\}$  in  $R^d$  with noise parameter  $\sigma$ , we consider two types of (correlated) weighted complete graphs with edge weights given by  $A_{i,j} = \langle X_i, X_j \rangle$ ,

$B_{i,j} = \langle Y_i, Y_j \rangle$ . The goal is to recover the hidden vertex correspondence  $\pi^*$  based on the observed matrices  $A$  and  $B$ . For the low-dimensional regime where  $d = O(\log n)$ , Wang, Wu, Xu, and Yolou established the information thresholds for exact and almost exact recovery in matching correlated Gaussian geometric models. They also conducted numerical experiments for the classical Uneyama algorithm. In our work, we prove that this algorithm achieves exact recovery of  $\pi^*$  when the noise parameter  $\sigma = o(d^{-3}n^{-2/d})$ , and almost exact recovery when  $\sigma = o(d^{-3}n^{-1/d})$ . Our results approach the information thresholds up to a  $\text{poly}(d)$  factor in the low-dimensional regime.

• **The algorithmic phase transition of random graph alignment problem.**

*Preprint:* <https://arxiv.org/abs/2307.06590>, *submitted*

Coauthors: Hang Du and Rundong Huang

**Abstract:** We study the graph alignment problem over two independent Erdős-Rényi graphs on  $n$  vertices, with edge density  $p$  falling into two regimes separated by the critical window around  $p_c = \sqrt{\log n/n}$ . Our result reveals an algorithmic phase transition for this random optimization problem: polynomial-time approximation schemes exist in the sparse regime, while statistical-computational gap emerges in the dense regime. Additionally, we establish a sharp transition on the performance of online algorithms for this problem when  $p$  lies in the dense regime, resulting in a  $\sqrt{8/9}$  multiplicative constant factor gap between achievable and optimal solutions.

• **A polynomial-time approximation scheme for the maximal overlap of two independent Erdős-Rényi graphs.**

*Random Structures and Algorithms* (2024), 1-38. <https://doi.org/10.1002/rsa.21212>

Coauthors: Jian Ding and Hang Du

**Abstract:** We presented a polynomial-time algorithm that finds a vertex correspondence which maximizes the overlap of two independent Erdős-Rényi graphs with a constant arbitrarily close to 1 compared with the asymptotic of the maximal overlap. This result gives a new example to the few problems that efficient algorithms exist for random instances while worst-cases are known to be NP-hard.

## Awards

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| • National Scholarship     | October, 2019/Shandong University |
| • National Scholarship     | October, 2020/Shandong University |
| • President Scholarship    | October, 2020/Shandong University |
| • Schlumberger Scholarship | October, 2023/Peking University   |
| • President Scholarship    | May, 2024/Peking University       |

## LANGUAGE

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Chinese(native), English(fluent)