

# 2021 北大 概率论研究生 学术报告

单位：北大 理学院

时间：2021年9月13日，13:00-17:30

地点：北大 理学院 楼 1114

组织者：高帆、黄子、吴昊

注意事项：

- (1) 请大家自觉遵守防疫要求，佩戴口罩，保持安全距离。我们会在会场备有消毒液，酒精洗手液。
- (2) 请全体同学确认自己的宿舍，手机：是否更改，若更改请 刘勇老师联系。请同学提供自己的宿舍号，手机：号， 大邮箱“pku.edu.cn” 地址。将邮箱名设为： 自己姓名相关的字母，而 是数字。请将个人信息发给刘勇老师(liuyong@math.pku.edu.cn)。
- (3) 同学在会议的开始需要做自我介绍，请同学提供电子版清晰照片 张，在会议开始前发到吴昊邮箱1701110057@pku.edu.cn, 方便自我介绍在大屏幕 显示。

## 会议日程

时间	内容
; 持	黄
13:00-13:10	请 生自我介绍
13:10-13:30	高 帆 师 章复熹 题目: Multiple points on the boundaries of Brownian loop-soup clusters.
13:30-13:50	黄 师 刘勇 题目: Large Deviation Principle for Empirical Measure of Once-reinforced Random Walk on Finite Graphs.
13:50-14:10	吴 师 蒋 题目: Large deviations of the empirical measure and the empirical flow for Markov renewal processes.
14:10-14:30	何 师 葛 题目: Nonequilibrium variational approach to Onsager-Joyce-Montgomery theory of stochastic 2-D vorticity dynamics.
14:30-14:50	拍照
; 持	高 帆
14:50-15:10	刘 师 刘勇 题目: Uniqueness of the 2D Navier-Stokes equations with degenerate stochastic forcing.
15:10-15:30	高 帆 师 艳霞 题目: Branching Brownian motion in a periodic environment and pulsating travelling waves.
15:30-15:45	蔡振豪 师 张 题目: On Phase Transition of the Finitary Random Interacements.
15:45-16:00	何 萍 师 刘勇 题目: Convergence of Density of Random Variable in Complex Wiener-Itô Chaos.
16:00-16:15	休息15分钟
; 持	吴
16:15-16:30	侯 师 艳霞 题目: The Seneta-Heyde scaling for the supercritical super-Brownian motion.
16:30-16:45	彭 力 师 葛 题目: Moment Based Reconstruction of Gene Regulatory Networks in Cellular State Transitions.
16:45-17:00	惠 师 葛 题目: Neighborhood contrastive clustering with mask estimation for scRNA-seq data.
17:00-17:15	蔡依茹 师 张 题目: A multiscale stochastic criminal behavior model and the convergence to a piecewise-deterministic-Markov-process limit.
17:15-17:30	邀请 剑 授点评

## 题目 摘•

### Multiple points on the boundaries of Brownian loop-soup clusters

报告◦ : 高帆, Z 士生, 师 章复熹

摘• : We compute the a.s. Hausdorff dimensions of simple and double points on the boundaries of clusters in a Brownian loop-soup with intensity  $c \in (0, 1]$  in any planar domain with harmonically non-trivial boundary. For all  $c \in (0, 1)$  the set of double points on cluster boundaries has positive dimension, hence is non-empty. For the critical intensity  $c = 1$ , we show that there a.s. do *not* exist double points on cluster boundaries, answering an open question in [Qian 2021]. We also show that simple and double points are a.s. dense on every portion of boundary of every cluster in a Brownian loop-soup, when they exist. Our results rely on the generalized disconnection exponents defined and computed in [Qian 2021]. As an intermediate result, we prove a separation lemma for the loop-soup setting, which implies up-to-constants estimates for the generalized non-intersection and non-disconnection probabilities.

### Large Deviation Principle for Empirical Measure of Once-reinforced Random Walk on Finite Graphs

报告◦ : 黄○‡, Z 士生, 师 刘勇

摘• : Once-reinforced random walk (ORRW)  $X_n$  on graph  $G = (V, E)$  is a kind of special reinforced random walk (RRW) with transition probability

$$P(X_{n+1} = u | X_n = v, \mathcal{F}_n) = \begin{cases} \frac{w_n(u, v)}{\sum_{u' \sim v} w_n(u', v)}, & u \sim v, \\ 0, & \text{otherwise.} \end{cases}$$

where  $w_n(e)$  equals to 1 if edge  $e$  has not been traversed before time  $n$  and equals to  $\delta$  otherwise. In this talk I will discuss LDP for the empirical measure of ORRW on finite connected graphs by weak convergence approach and show the phase transition of rate function at critical point  $\delta_c = 1$ . Furthermore, I will show the critical exponent of exponential integrability of edge cover time  $C_E := \inf\{n : \forall e \in E, \exists m < n \text{ s.t. } \{X_m, X_{m+1}\} = e\}$  and discuss the reason for appearance of phase transition of rate function.

### Large deviations of the empirical measure and the empirical flow for Markov renewal processes

报告◦ : 吴É p, Z 士生, 师 蒋¾C

摘• : We consider Markov renewal processes on countable state space and prove a joint large deviation principle for the empirical measure and the empirical flow, which is endowed with the so-called bounded weak\* topology or strong topology. As an application, under the weaker condition than previous works, we also give the joint LDP for Markov chains.

## Nonequilibrium variational approach to Onsager-Joyce-Montgomery theory of stochastic 2-D vorticity dynamics.

报告人：Hao Zhang, Z 士生, 导师 葛颢

摘要：We are interested in characterizing large time coherent structures of a 2-D stochastic vortex dynamics, taking Navier-Stokes equation as the mean field limit. We have proved a path space level large deviation result for this model when the number of vortices goes to infinity. We are now studying the long time behaviour of large deviation rate function, and trying to derive an equilibrium micro-canonical variational principle from such a non-equilibrium stochastic model by first principle.

## Uniqueness of the 2D Navier-Stokes equations with degenerate stochastic forcing

报告人：刘平, Z 士生, 导师 刘勇

摘要：The uniqueness of invariant measure is an interesting topic in the theory of Markov processes. One way to demonstrate the uniqueness of ergodic measure is through the property that its Ergodic Measures are Disjointedly Supported (the EMDS property) and the weak topological irreducibility. While the EMDS property can be guaranteed under some certain conditions, including the strong Feller property or the e-property, such notions might be restricted in some cases. In this short talk, we employ a much weaker notion introduced by J. Jaroszewska in 2013, or F. Gong, Y. Liu in 2015, the eventual continuity, to prove the uniqueness of the invariant measure for the two-dimensional stochastic Navier-Stokes equations on a domain with a degenerate multiplicative noise.

## Branching Brownian motion in a periodic environment and pulsating travelling waves

报告人：何帆, Z 士生, 导师 闫艳霞

摘要：We study the limits of the additive martingale and derivative martingale for one-dimensional branching Brownian motion in a periodic environment. We use the limits to give probabilistic representations of pulsating travelling waves of the corresponding F-KPP equation in a periodic medium. The key for these results is due to the spine decomposition and martingale change of measure for branching Brownian motion.

## On Phase Transition of the Finitary Random Interlacements

报告人：蔡振豪, Z 士生, 导师 张煜

摘要：Finitary Random Interlacements (FRI) is a two-parameter stochastic model introduced by L. Bowen. Later, E.B. Procaccia, J. Ye, and Y. Zhang proved that FRI has phase transitions. Our recent work shows the equivalence between four kinds of critical

values of FRI. As corollaries, we prove the sharpness of phase transition and the continuity of critical value for FRI. This report also includes some rigorous results on the phase transition of FRI, such as upper and lower bounds for critical values in some special cases.

### **Convergence of Density of Random Variable in Complex Wiener-Itô Chaos**

报告人 : 何萍, Z 士生, 导师 刘勇

摘要 : The aim of this report is to introduce the uniform convergence of the densities of random variables in complex Wiener-Itô Chaos, which are functionals of an underlying complex Gaussian process, to a normal density. Precise estimates for the uniform distance are derived by using the techniques of Malliavin calculus, the result of real Wiener-Itô Chaos, and the relationship between real and complex Wiener-Itô Chaos.

### **The Seneta-Heyde scaling for the supercritical super-Brownian motion**

报告人 : 侯睿, Z 士生, 导师 闫艳霞

摘要 : We consider the additive martingale  $W_t(\lambda)$  and the derivative martingale  $\partial W_t(\lambda)$  for one-dimensional supercritical super-Brownian motions with general branching mechanism. In the critical case  $\lambda = \lambda_0$ , we prove that  $\sqrt{t}W_t(\lambda_0)$  converges in probability to a positive limit, which is a constant multiple of the almost sure limit  $\partial W_\infty(\lambda_0)$  of the derivative martingale  $\partial W_t(\lambda_0)$ . We also prove that, on the survival event,  $\limsup_{t \rightarrow \infty} \sqrt{t}W_t(\lambda_0) = \infty$  almost surely.

### **Moment Based Reconstruction of Gene Regulatory Networks in Cellular State Transitions**

报告人 : 彭力, Z 士生, 导师 葛颢

摘要 : Nowadays the advance in single-cell RNA sequencing (scRNA-seq) technology allows us to measure the expression level of each gene in every cell, providing us with large-scale, high-dimensional data where novel insights and discoveries can be acquired for further study. In this sense, we propose a covariance restricted sparse linear regression (COSLIR) method to reconstruct the gene regulatory network (GRN) from scRNA-seq data in cell-state transition processes. Different existing approaches, which are mostly based on mutual information and pseudo-time prediction, COSLIR predicts the GRN directly from the data without much loss of accuracy. In COSLIR, we assume a linear relation between the gene expression level at two stages. The GRN is reconstructed through solving an optimization problem concerning only the first and second moments of the sample distributions. The bootstrap strategy as well as the clip threshold method is applied to increase the precision and stability of the estimation. Simulation studies show the perfect accuracy of COSLIR in various situations. COSLIR is also evaluated on several real datasets, and the performance is comparable with other methods relying on the pseudo-time prediction. These numerical experiments indicate COSLIR is a promising approach for GRN reconstruction and further downstream analysis.

## **Neighborhood contrastive clustering with mask estimation for scRNA-seq data**

报告人：王惠，Z 士生，导师 葛颢

摘要：The emergence and rapid development of single-cell RNA sequencing (scRNA-seq) make it possible to study heterogeneity of individual cell traits, and cell clustering is one of the most important procedures in scRNA-seq analysis. However, the noisy, high-dimensional and massive nature of scRNA-seq data introduces challenges in the clustering analysis. Here we propose a two-stage scRNA-seq clustering learning framework called scNAME utilizing neighborhood contrastive learning and an ancillary mask estimation task to fully explore the correlation among genes as well as the similarity between cells. We have proved that scNAME performs superiority comparing with other competitive scRNA-seq data clustering methods in both simulated and real data experiments.

## **A multiscale stochastic criminal behavior model and the convergence to a piecewise-deterministic-Markov-process limit**

报告人：蔡依茹，硕士生，导师 张昱

摘要：Residential burglary is one of the toughest issues in modern society. A quantitative, informative and applicable model of crime is needed to help us to understand