应用数学所近期发表的若干重要成果汇编

成果一.

我院袁谦助理研究员的论文 PLANAR VISCOUS SHOCKS WITH PERIODIC PERTURBATIONS FOR SCALAR MULTIDIMENSIONAL VISCOUS CONSERVATION LAWS 被 SIAM JOURNAL ON MATHEMATICAL ANALYSIS 接收发表。

摘要：
This paper studies a Cauchy problem for a scalar multidimensional (multi-d) viscous convex conservation law, in which the initial data is a planar viscous shock with a multi-d periodic perturbation. We show that if the wave-strength and perturbation are both small, then the viscous shock is stable in the L\infty (Rn) space with an exponential decay rate. One contribution of the paper is to establish a new framework to study the stability of viscous shocks in multiple dimensions, where the elementary energy method with the antiderivative technique can be used. The idea is to decompose the multi-d perturbation into a one-dimensional function and a multi-d remainder, where the former can well define its antiderivative and the latter satisfies the Poincare'\ inequality over a periodic domain.

论文链接：http://dx.doi.org/10.1137/21M1462453

成果二.

我院肖惠副研究员与合作者的论文 LARGE DEVIATION EXPANSIONS FOR THE COEFFICIENTS OF RANDOM WALKS ON THE GENERAL LINEAR GROUP 被 ANNALS OF PROBABILITY 接收发表。

摘要：
Consider (gn)n>1 a sequence of independent and identically distributed random matrices and the left random walk Gn := gn . . . g1, n > 1 on the general linear group GL(d, R). Under suitable conditions we establish a Bahadur-Rao-Petrov type large deviation expansion for the coefficient (f, Gnv) of the product Gn, where v & epsilon; Rd and f & epsilon; (Rd)*. In particular, we obtain an explicit rate function in the large deviation principle, thus im-proving significantly the known large deviation bounds. A local limit theorem with large deviations for the coefficients and large deviation expansions under the change of probability measure are also proved.

论文链接：http://dx.doi.org/10.1214/23-AOP1621

成果三.

我院骆顺龙研究员与合作者的论文 Probing correlations in two-mode bosonic fields via Gaussian noise channels 被 PHYSICAL REVIEW A 接收发表。

摘要：
Gaussian noise channels arise naturally in many physical situations and play an important role in information transmission involving continuous-variable quantum systems. In this work we employ Gaussian noise channels to probe and characterize correlations in two-mode bosonic fields. Based on the fact that local channels often cause more decoherence for global states than for local states due to correlations, we introduce a notion of conditional coherence relative to a local channel, which is defined as the difference between the global and local decoherence caused by the channel. We discuss its connections with quantum discord and relative quantum Fisher information and propose a class of correlation quantifiers for two-mode bosonic states in terms of conditional coherence relative to local Gaussian noise channels. We prove that any nonproduct state exhibits such correlations and show that these correlation quantifiers are measures of total correlations, which may include both classical and quantum parts. We further illustrate these correlation quantifiers through several typical two-mode bosonic states and make a comparative study between these correlation quantifiers and other known ones such as entanglement and discord.

论文链接：http://dx.doi.org/10.1103/PhysRevA.107.062415

成果四.

我院孙六全研究员与合作者的论文 A mark-specific quantile regression model 被 BIOMETRIKA 接收发表。

摘要：
Quantile regression has become a widely used tool for analysing competing risk data. However, quantile regression for competing risk data with a continuous mark is still scarce. The mark variable is an extension of cause of failure in a classical competing risk model where cause of failure is replaced by a continuous mark only observed at uncensored failure times. An example of the continuous mark variable is the genetic distance that measures dissimilarity between the infecting virus and the virus contained in the vaccine construct. In this article, we propose a novel mark-specific quantile regression model. The proposed estimation method borrows strength from data in a neighbourhood of a mark and is based on an induced smoothed estimation equation, which is very different from the existing methods for

competing risk data with discrete causes. The asymptotic properties of the resulting estimators are established across mark and quantile continuums. In addition, a mark-specific quantile-type vaccine efficacy is proposed and its statistical inference procedures are developed. Simulation studies are conducted to evaluate the finite sample performances of the proposed estimation and hypothesis testing procedures. An application to the first HIV vaccine efficacy trial is provided.

论文链接：http://dx.doi.org/10.1093/biomet/asad039

成果五.

我院朱湘婵研究员与合作者的论文Global Existence and Non-Uniqueness for 3D Navier-Stokes Equations with Space-Time White Noise被ARCHIVE FOR RATIONAL MECHANICS AND ANALYSIS接收发表。

摘要：

We establish that global-in-time existence and non-uniqueness of probabilistically strong solutions to the three dimensional Navier-Stokes system driven by space-time white noise. In this setting, solutions are expected to have space regularity of at most -1/2-kappa for any kappa >0. Consequently, the convective term is ill-defined analytically and probabilistic renormalization is required. Up until now, only local well-posedness has been known. With the help of paracontrolled calculus we decompose the system in a way which makes it amenable to convex integration. By a careful analysis of the regularity of each term, we develop an iterative procedure which yields global non-unique probabilistically strong paracontrolled solutions. Our result applies to any divergence free initial condition in L2B infinity,infinity -1+kappa, kappa >0, and also implies non-uniqueness in law.

论文链接：http://dx.doi.org/10.1007/s00205-023-01872-x

成果六.

我院董昭研究员与合作者的论文GLOBAL WELL-POSEDNESS AND REGULARITY OF STOCHASTIC 3D BURGERS EQUATION WITH MULTIPLICATIVE NOISE被SIAM JOURNAL ON MATHEMATICAL ANALYSIS接收发表。

摘要：

By utilizing the so-called Doss-Sussman transformation, we link our stochastic 3D Burgers equation with linear multiplicative noise to a random 3D Burger equation. With the help of techniques from partial differential equations (PDEs) and probability, we establish the global wellposedness of stochastic 3D Burgers with the diffusion coefficient being constant. Next, by developing a solution which is orthogonal with

the gradient of coefficient of the noise, we extend the global well-posedness to a more general case in which the diffusion coefficient is spatial dependent, i.e., it is a function of the spatial variable. Our results and methodology pave a way to extend some regularity results of stochastic 1D Burgers equation to stochastic 3D Burgers equations.

论文链接：http://dx.doi.org/10.1137/21M1413377

成果七.

我院骆顺龙研究员与合作者的论文 Partial coherence versus entanglement 被 PHYSICAL REVIEW A 接收发表。

摘要：

We study partial coherence and its connection with entanglement. First, we provide a sufficient and necessary condition for bipartite pure-state transformation under partially incoherent operations: A bipartite pure state can be transformed to another one if and only if a majorization relationship holds between their partial coherence vectors. As a consequence, we introduce the concept of maximal partial coherent states in the sense that they can be used to construct any bipartite state of the same system via partial incoherent operations. Second, we provide a strategy to construct measures of partial coherence by use of symmetric concave functions. Third, we establish the relationship between partial coherence and entanglement. We show that the minimal partial coherence under local unitary transformations is also a measure of entanglement for bipartite pure states, which can be extended to all mixed states by convex-roof extension. Conversely, every entanglement measure can be constructed as a partial coherence measure, and we further show that partial coherence measures are induced through maximal entanglement under partially incoherent operations for bipartite pure states.

论文链接：http://dx.doi.org/10.1103/PhysRevA.108.012416

成果八.

我院张世华研究员与合作者的论文 Spatiotemporal transcriptomic atlas reveals the dynamic characteristics and key regulators of planarian regeneration 被 NATURE COMMUNICATIONS 接收发表。

摘要：

Cui et al. present a comprehensive three-dimensional spatiotemporal transcriptome landscape of planarian regeneration. They identified a novel pluripotent neoblast subtype and new spatially specific genes essential to tissue regeneration. Whole-body regeneration of planarians is a natural wonder but how it occurs remains elusive. It

requires coordinated responses from each cell in the remaining tissue with spatial awareness to regenerate new cells and missing body parts. While previous studies identified new genes essential to regeneration, a more efficient screening approach that can identify regeneration-associated genes in the spatial context is needed. Here, we present a comprehensive three-dimensional spatiotemporal transcriptomic landscape of planarian regeneration. We describe a pluripotent neoblast subtype, and show that depletion of its marker gene makes planarians more susceptible to sub-lethal radiation. Furthermore, we identified spatial gene expression modules essential for tissue development. Functional analysis of hub genes in spatial modules, such as plk1, shows their important roles in regeneration. Our three-dimensional transcriptomic atlas provides a powerful tool for deciphering regeneration and identifying homeostasis-related genes, and provides a publicly available online spatiotemporal analysis resource for planarian regeneration research.

论文链接：http://dx.doi.org/10.1038/s41467-023-39016-0