新疆大学应用数学青年学者论坛

数学与系统科学学院

新疆大学

December 21-23, 2018

论坛简介：

为加强新疆大学与各对口支援高校数学学科的学术交流，促进新疆大学的双一流学科建设和发展，新疆大学数学与系统科学学院拟举办"新疆大学青年学者论坛"。此次论坛聚焦于应用数学。邀请了北京师范大学，清华大学，新疆大学和武汉大学共 17 位优秀的青年应用数学家参与此次学术活动。

组织者：

蒋海军	新疆大学数学与系统科学学院
李静	新疆大学数学与系统科学学院
张建宏	新疆大学数学与系统科学学院
郑春雄	清华大学数学科学系
	新疆大学数学与系统科学学院

论坛地点：

新疆大学数学与系统科学学院 207 报告厅

联系人：

李静

Email: 601586525@qq.com
移动电话: 131-9981-5206

郑春雄

Email: czheng@math.tsinghua.edu.cn
移动电话: 182-1060-4270

论坛日程安排

十二月二十二日(Dec 22), 星期六 (Saturday)		
10:10-10:40	注册	
10:40-11:00	新疆大学副校长、数学学院院长 蒋海军	致辞
Morning Session I (主持人：郑春雄)		
11:00-11:30	北京师范大学　张辉	柱形受限下聚合物球状相的形变
11:30-12:00	新疆大学　宝音都仍	**Domination in graphs**
12:00-12:30	集体合影	
Morning Session II (主持人：冯新龙)		
12:30-13:00	清华大学　史作强	**PDE-based methods in learning manifold**
13:00-13:30	北京师范大学 陈华杰	**Locality of the reduced Hartree-Fock model with Yukawa potential**
13:30-14:00	新疆大学　于志永	**Distributed consensus for multi-agent systems via directed spanning tree based adaptive control**
午间休息		
Afternoon Session I (主持人:张辉)		
16:00-16:30	新疆大学　田应智	**On connectivity keeping subtrees in k-connected graphs**
16:30-17:00	清华大学　陈俊清	**A direct sampling method for inverse electromagnetic scattering problem**
17:00-17:30	武汉大学　戴书洋	**Modeling and simulations of continuum dislocation array dynamics**
17:30-18:00	会议休息	

Afternoon Session II	**(主持人：陈俊清）**	
18:00-18:30	新疆大学　　张龙	**A parasitism-mutualism-predation model consisting of crows, cuckoos and cats with stage-structure and maturation delays on crows and cuckoos**
18:30-19:00	武汉大学　　张晓平	**A vertex-centered and positivity-preserving scheme for anisotropic diffusion problems on arbitrary polygonal grids**
19:00-19:30	北京师范大学 纪光华	**A second order stable scheme for tensor model of liquid crystal polymers flow**

十二月二十三日(Dec 23), 星期日 (Sunday)

Morning Session I.	**(主持人：戴书洋)**	
10:30-11:00	清华大学　　胡创强	**Complete weight distribution and MacWilliams identities for asymmetric quantum codes**
11:00-11:30	北京师范大学 曹外香	**Some recent development in superconvergence of discontinuous Galerkin methods for time-dependent partial differential equations**
11:30-12:00	武汉大学　　张继伟	非局部模型的人工边界条件设计
12:00-12:30	会议休息	

Morning Session II.	**(主持人：宝音都仍)**	
12:30-13:00	北京师范大学 潘亮	**Two-stage fourth-order gas-kinetic scheme Euler and Navier-Stokes solutions**
13:00-13:30	清华大学　　荆文甲	**On the homogenization of Dirichlet problems in perforated domain**
13:30-14:00	新疆大学　　苏海燕	**Iterative methods in penalty finite element discretization for the steady MHD equations**
午间休息		

Domination in graphs

新疆大学 宝音都仍

A vertex subset S of a graph G is called a dominating set of G if each vertex of G either belongs to S or is adjacent to an element of S in G. The domination number of G is the cardinality of a minimum dominating set of G. In this talk we will report some recent results on domination in graphs.

Some recent development in superconvergence of discontinuous Galerkin methods for time-dependent partial differential equations

北京师范大学 曹外香

In this talk, we briefly review some recent development in superconvergence of three types of DG methods for time-dependent partial differential equations, including the standard discontinuous Galerkin (DG) method, the local discontinuous Galerkin (LDG) method and the direct discontinuous Galerkin (DDG) method. A survey of our own works on superconvergence results for various time-dependent partial differential equations is presented, and superconvergence phenomena of aforementioned three types of DG solutions at some special points (including the function value and derivative value approximation), as well as the cell average error and supercloseness results, are all discussed.

Locality of the reduced Hartree-Fock model with Yukawa potential

北京师范大学 陈华杰

We establish a locality estimate for the reduced Hartree-Fock model with Yukawa potential. Based on the locality result, we demonstrate the thermodynamic limit of this model for lattice systems with local defects. We also discuss the application to QM/MM coupling schemes for crystalline defects.

A direct sampling method for inverse electromagnetic scattering problem

清华大学 陈俊清

I will talk about a direct imaging method based on reverse time migration algorithm for imaging extended targets using electromagnetic waves at a fixed frequency in free space and rectangular waveguide. The imaging functional is defined as the imaginary part of the cross-correlation of the Green function for Helmholtz equation and the back-propagated electromagnetic field. The resolution of our RTM method for penetrable extended targets is studied by virtue of Helmholtz-Kirchhoff identity, which implies that the imaging functional always peaks in the target.

Modeling and simulations of continuum dislocation array dynamics

武汉大学 戴书洋

We first present a simulation method for the dynamics of dislocation arrays. In this numerical method, dislocation arrays are considered as continuous surfaces in 3D, and the level set representation is used for these dislocation array surfaces. The driving force of the dislocation array surfaces comes from both the long-range interaction and their local curvature effect. Simulations are performed for dislocation arrays bypassing different particles under applied stress. We also consider systems of parallel straight dislocation walls and develop continuum descriptions for the short-range interactions of dislocations by using asymptotic analysis. The short-range interaction terms ensure strong stability property of the continuum model that is possessed by the discrete dislocation dynamics model. The model is validated by comparisons with the discrete dislocation simulation results.

Complete weight distribution and MacWilliams identities for asymmetric quantum codes

清华大学 胡创强

In 1997, Shor and Laflamme defined the weight enumerators for quantum error-correcting codes and derived a MacWilliams identity. We extend their work by introducing our double weight enumerators and complete weight enumerators. The MacWilliams identities for these enumerators can be obtained similarly. With the help of MacWilliams identities, we obtain various bounds for asymmetric quantum codes.

A second order stable scheme for tensor model of liquid crystal polymers flow

北京师范大学 纪光华

The hydrodynamic Q-tensor model has been used for studying flows of liquid crystals polymers. It can be derived from a variational approach together with the generalized Onsager principle, in which the total energy decreases in time. In this paper, we derive a linear, second order semi-discrete scheme in time for the model. The scheme is developed following the "Scalar auxiliary variable (SAV)" strategy, we prove that the scheme is unconditionally energy stable, uniquely solvable. The numerical simulations show the 2nd order convergence in time and energy decreasing, which agreed with our theoretical analysis.

On the homogenization of Dirichlet problems in perforated domain

清华大学 荆文甲

We consider the homogenization of Dirichlet problems for the Laplace operator in

perforated domains, and present a unified approach adaptive to the ratio between the sizes of the perforating holes and the typical cells. For finite hole-cell size ratios, we adopt the standard oscillating test function method; for vanishing hole-cell size ratios, we add in the asymptotic behaviors of a properly rescaled cell problem. When the hole-cell size ratio is critically small, our method recovers "the strange term from nowhere" due to Cioranescu and Tartar; the method also reveals how this critical case intrinsically relates to the case of relatively larger holes, where the limiting equation becomes algebraic, and to the case of smaller holes, where the limiting equation ignores the holes. I will comment on quantitative estimates and on the random settings.

Two-stage fourth-order gas-kinetic scheme Euler and Navier-Stokes solutions

北京师范大学　潘亮

For the one-stage third-order gas-kinetic scheme (GKS), successful applications have been achieved for the three-dimensional compressible flows. The high-order accuracy of the scheme is obtained by integrating a multidimensional time-accurate gas distribution function over the cell interface within a time step without using Gaussian quadrature points and Runge-Kutta time-stepping technique. However, to the further increase of the order of the scheme, such as the fourth-order one, the one step formulation becomes very complicated for the multidimensional flow. Recently, a two-stage fourth-order GKS with high efficiency has been constructed for two-dimensional inviscid and viscous flow computations and the scheme uses the time accurate flux function and its time derivatives. In this paper, a fourth-order GKS is developed for the three-dimensional flows under the two-stage framework. Based on the three-dimensional WENO reconstruction and flux evaluation at Gaussian quadrature points on a cell interface, the high-order accuracy in space is achieved first. Then, the two-stage time stepping method provides the high accuracy in time. In comparison with the formal third-order GKS the current fourth-order method not only improves the accuracy of the scheme, but also reduces the complexity of the gas-kinetic flux solver greatly. More importantly, the fourth-order GKS has the same robustness as the second-order shock capturing scheme. Numerical results validate the outstanding reliability and applicability of the scheme for three-dimensional flows, such as the cases related to turbulent simulations.

PDE-based methods in learning manifold

清华大学　史作强

Manifold is very powerful to model the low dimensional structure hidden in high dimensional data. In this talk, I will introduce several PDE-based models to study the manifolds in image processing and data analysis. We will reveal the close connections between PDEs and some deep neural networks. Theoretical analysis and numerical simulations show that PDEs on manifold provide a powerful tool to understand high dimensional data.

Iterative methods in penalty finite element discretization for the steady MHD equations

新疆大学 苏海燕

This paper characterizes one penalty finite element method for the incompressible MHD equations. The method is an interesting combination of the classic iterative schemes (Stokes, Newton and Oseen iterations) with two different finite element pairs P1b–P1–P1b and P1–P0-P1. Moreover, the rigorous analysis of stability and error estimate for the proposed methods are given. Finally, the applicability and effectiveness of the presented schemes are illustrated in several numerical experiments.

On connectivity keeping subtrees in k-connected graphs

新疆大学 田应智

In [W. Mader, Connectivity keeping paths in k-connected graphs, J. Graph Theory 65 (2010) 61-69.], Mader conjectured that for every positive integer k and every finite tree T with order m, every k-connected, finite graph G with $\delta(G)\geq \lfloor\frac{3}{2}k\rfloor+m-1$ contains a subtree T' isomorphic to T such that $G-V(T')$ is k-connected. In the same paper, Mader proved that the conjecture is true when T is a path. Diwan and Tholiya [A.A. Diwan, N.P. Tholiya, Non-separating trees in connected graphs, Discrete Math. 309 (2009) 5235-5237.] verified the conjecture when $k=1$. In this talk, we will verify Mader's conjecture for stars, double-stars and two classes of trees when $k=2$.

For digraphs, Mader [J. Graph Theory 69 (2012) 324-329] conjectured that every k-connected digraph D with minimum semi-degree $\delta(D)=min\{\delta^+(D),\delta^-(D)\}\geq 2k+m-1$ for a positive integer m has a dipath P of order m with $\kappa(D-V(P))\geq k$. The conjecture has only been verified for the dipath with $m=1$, and the dipath with $m=2$ and $k=1$. In this talk, we will prove that every strongly connected digraph with minimum semi-degree $\delta(D)=min\{\delta^+(D),\delta^-(D)\}\geq m+1$ contains an oriented tree T isomorphic to some given oriented stars or double-stars with order m such that $D-V(T)$ is still strongly connected.

Distributed consensus for multi-agent systems via directed spanning tree based adaptive control

新疆大学 于志永

The leader-following and leaderless consensus problems of multi-agent systems with linear and nonlinear dynamics are studied. In order to overcome the drawback that the spectrum of the Laplacian matrix must be known a prior for the design of control gains, a new distributed consensus protocol, updating the weights of the directed spanning tree, is developed. A scheme for reordering the nodes is proposed, and by using this scheme, an equivalent lemma for achieving consensus is given. Applying the developed method, and Lyapunov stability theory, some distributed adaptive laws are designed on the coupling weights in a directed network. It is found that the consensus can be reached by randomly choosing directed spanning tree and using the developed distributed adaptive laws. Furthermore, by reordering the nodes and using the proposed adaptive laws, one obtains that the leader-following consensus can be reached by pinning a small fraction of nodes if the leader node is the root of the directed spanning tree. For both with the leader and leaderless cases, it is also found that the weight of the directed spanning tree depends on the position of the head node in the directed spanning tree.

柱形受限下聚合物球状相的形变

北京师范大学 张辉

高分子聚合物在不同的受限条件下会自组装形成不同的微观相结构，我们基于自洽平均场理论，利用数值方法研究了 AB 两嵌段共聚物溶入 A 均聚物所形成的球状相在柱形受限环境下的相行为. 由于 AB 两嵌段共聚物与 A 均聚物所形成的溶液在不同的临界胶束浓度(CMC)下可以形成不同的微观相(包括层状相、柱状相和球状相等). 这里首先根据不同参数条件下的临界胶束浓度，确定不同长度的均聚物链稳定的球状相结构，然后研究该球状相在柱形受限环境下的形变.通过数值模拟, 我们发现球状相在柱形受限的环境下呈现出了典型的毛细凝聚现象, 进一步, 我们通过分析球壳中各物质的浓度分布, 发现在柱形管的半径逐渐减小的过程中, 球壳的表面 AB 两嵌段共聚物中 B 的浓度分布不均匀, 表现出耗尽效应(depletion effect), 这一现象很好的解释了中科大吴奇院士所做的物理实验.

非局部模型的人工边界条件设计

武汉大学 张继伟

近场动力学（peridynamics）近年来受到了很大的关注，在数学理论和算法分析方面取得了一些进展。对于无界域非局部模型，计算量要求较大，利用人工

边界将计算区域限制在较小宏观尺度是实现大规模数值模拟的关键技术。由于非局部效应，传统设计局部模型的人工边界法，直接应用到非局部模型是非常困难的，因此，需要引入新的方法和技巧。 本报告，我们将以典型线性问题作为出发点， 系统发展和设计非局部模型的人工边界条件。

A parasitism-mutualism-predation model consisting of crows, cuckoos and cats with stage-structure and maturation delays on crows and cuckoos

新疆大学 张龙

In this paper, a parasitism–mutualism–predation model is proposed to investigate the dynamics of multi- interactions among cuckoos, crows and cats with stage-structure and maturation time delays on cuckoos and crows. The crows permit the cuckoos to parasitize their nestlings (eggs) on the crow chicks (eggs). In return, the cuckoo nestlings produce a malodorous cloacal secretion to protect the crow chicks from predation by the cats, which is apparently beneficial to both the crow and cuckoo population. The multi- interactions, i.e., parasitism and mutualism between the cuckoos (nestlings) and crows (chicks), predation between the cats and crow chicks are modeled both by Holling-type II and Beddington–DeAngelis-type functional responses. The existence of positive equilibria of three subsystems of the model are discussed. The criteria for the global stability of the trivial equilibrium are established by the Krein–Rutman theorem and other analysis methods. Moreover, the threshold dynamics for the coexistence and weak persistence of the model are obtained, and we show, both analytically and numerically, that the stabilities of the interior equilibria may change with the increasing maturation time delays. We find there exists an evident difference in the dynamical properties of the parasitism–mutualism–predation model based on whether or not we consider the effects of stage-structure and maturation time delays on cuckoos and crows. Inclusion of stage structure results in many varied dynamical complexities which are difficult to encompass without this inclusion.

A vertex-centered and positivity-preserving scheme for anisotropic diffusion problems on arbitrary polygonal grids

武汉大学 张晓平

We suggest a new positivity-preserving finite volume scheme for anisotropic diffusion problems on arbitrary polygonal grids. The scheme has vertex-centered, edge-midpoint and cell-centered unknowns. The vertex-centered unknowns are primary and have finite volume equations associated with them. The edge-midpoint and cell-centered unknowns are treated as auxiliary ones and are interpolated by the primary unknowns, which makes the final scheme a pure vertex-centered one. Unlike most existing positivity-preserving schemes, the construction of the scheme is based

on a special nonlinear two-point flux approximation that has a fixed stencil and does not require the convex decomposition of the co-normal. In order to solve efficiently the nonlinear systems resulting from the nonlinear scheme, Picard method and its Anderson acceleration are discussed. Numerical experiments demonstrate the second-order accuracy and well positivity of the solution for heterogeneous and anisotropic problems on severely distorted grids. The high efficiency of the Anderson acceleration is also shown on reduction of the number of nonlinear iterations.