Abstract of Talks

In the multiple authors case, the name with $*$ is the speaker.

1. Solutions to elliptic gradient systems with symmetry

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Abstract: We examine spatially asymptotic states of symmetric solutions to $\Delta u - grad\, W(u) = 0$, $u : R^n \to R^n$ constructed by Alikakos and Fusco. Here W is equivariant under a finite reflection group and has $n+1$ nondegenerate minima. Passing to the limit as $x \to \infty$ in certain directions gives lower dimensional solutions with symmetry. We also prove the existence of solutions to three-fold symmetric elliptic systems in R^2 which have six-fold symmetry, asymptotically approaching each of the three minima of the potential as $|x| \to \infty$ in two antipodal sectors of angle $\pi/3$. This is joint work with N. Alikakos, G. Fusco, and P. Smyrnelis.

2. Calibration of Stochastic Volatility Models: An Optimal Control Approach

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Abstract: Market prices of options are directly observable and are widely used to recover the local volatility function that is assumed to be deterministic. However, empirical evidences show that volatility is stochastic. In this talk, we instead calibrate the stochastic volatility model from option prices. More precisely, we develop a robust optimal control approach for partial differential equations to recover the risk neutral drift term of stochastic volatility. Numerical results and empirical studies are presented as well. In contrast to existing literature, we aim to recover a time-dependent drift term that is not assumed to have special structure. However, we reveal that the risk neutral process of volatility recovered from market prices of options is indeed mean-reverting. This work is joint with Ling Tang.

3. Analysis for the Hydrodynamic Flow of Liquid Crystals

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Abstract: In this talk, we will introduce some recent progresses on the studies of the hydrodynamical flow of liquid crystals. We will talk about the derivation of the compressible model, the zero Mach limit of compressible model to the incompressible model, the global existence of small solutions in higher dimensions and a free boundary problem in 1-D. Some

recent results on the incompressible models are also given, including the global existence and the partially regular solutions.

4. Semi-classical limits of ground states of a nonlinear Dirac equation

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Abstract: We study the semi-classical states of the following nonlinear Dirac equation

$$-i\hbar\sum_{k=1}^{3}\alpha_k\partial_k w + a\beta w + V(x)w = W(x)g(|w|)w$$

for $x \in \mathbf{R}^3$ where the nonlinearity is of superlinear and subcritical growth as $|w| \to \infty$. The Dirac operator is unbounded from below and above so the associate energy functional is strongly indefinite. We develop an argument to establish the existence of least energy solutions for $\hbar$ small. We also describe the concentration phenomena of the solutions as $\hbar \to 0$.

5. Monotone traveling waves for delayed Lotka-Volterra competition systems

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Abstract: Consider the following reaction diffusion Lotka-Volterra competition system with intraspecific delay τ_1 and interspecific delay τ_2

$$\begin{cases} u_t - u_{xx} = u[1 - u(t-\tau_1, x) - a_1 v(t-\tau_2, x)] \\ v_t - dv_{xx} = rv[1 - v(t-\tau_1, x) - a_2 u(t-\tau_2, x)]. \end{cases}$$

The interspecific delay generally does not change the dynamics too much but the intraspecific delay considerably does. When $\tau_1 = 0$, the system is order-preserved and we obtain the existence of bistable traveling wave solutions connecting two semi-trivial states. When $\tau_2 = 0$, the system generally is not order-preserved for large τ_1. In such a case, we obtain a necessary and sufficient condition (i.e., the critical size of delay τ_1) for the existence of monostable traveling wave solutions connecting the extinction state to the coexistence state, and prove that such solutions are monotone and unique (up to translation). This talk is based on joint works with Dr. Jianhong Wu.

6. Quenching behavior for a singular predator-prey model

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Abstract: We study the quenching behavior for a system of two reaction-diffusion equations arising in the modelling of the spatio-temporal interaction of prey and predator populations in fragile environment. We first provide some sufficient conditions on the initial data to have finite time quenching. Then we classify the initial data to distinguish type I quenching and type II quenching, by introducing a delicate energy functional along with the help of some a priori estimates. Finally, we present some results on the quenching set. It can be a singleton, the whole domain, or a compact subset of the domain. This is a joint work with Arnaud Ducrot from Bordeaux, France.

7. Positive solution for quasilinear systems with critical growth

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Abstract: In this paper, we consider the following system:

$$\begin{cases} \Delta u + u\Delta u^2 + \alpha u^{\alpha-1}v^{\beta} + \lambda u^{\lambda-1}v^{\mu} = 0 & \text{in } \Omega \\ \Delta v + v\Delta v^2 + \beta u^{\alpha}v^{\beta-1} + \mu u^{\lambda}v^{\mu-1} = 0 & \text{in } \Omega \\ u > 0, v > 0 & \text{in } \Omega \\ u = 0, v = 0 & \text{on } \partial\Omega, \end{cases} \tag{P}$$

where $\Omega \subset \mathbb{R}^N (N \geq 3)$ is a smooth bounded domain. $\alpha, \beta, \lambda, \mu > 1$ are parameters with $\alpha + \beta = \frac{4N}{N-2}, 4 < \lambda + \mu < \frac{4N}{N-2}$. By using the perturbation method, we proved the existence of positive solutions for problem (P). Indeed, the method we are using in this paper can be applied to the more general quasilinear system.

8. An Application of Maslov Index to the Stability Analysis for Standing Pulses

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Abstract: We consider the reaction-diffusion system with skew-gradient structure. In such a system, a standing pulse can be identified with a homoclinic orbit of a Hamiltonian system. With the aid of Maslov index, we give a number of stability criteria for standing pulse solutions in FitzHugh-Nagumo system as well as skew-gradient systems. Moreover, some related properties to the Evans function will be illustrated. This is based on joint works with Prof. Chao-Nien Chen.

9. Nonlinear dynamic and pattern bifurcations in a model for spatial patterns in young mussel beds

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Abstract: Young mussel beds on soft sediments can display large-scale regular spatial patterns. This phenomenon can be explained relatively simply by a reactiondiffusionadvection (RDA) model of the interaction between algae and mussel, which includes the diffusive spread of mussel and the advection of algae. We present a detailed analysis of pattern formation in this RDA model. We derived the conditions for differential-flow instability that cause the formation of spatial patterns, and then systematically investigated how these patterns depend on model parameters. We also present a detailed study of the patterned solutions in the full nonlinear model, using numerical bifurcation analysis of the ordinary differential equations, which were obtained from the RDA model. We show that spatial patterns occur for a wide range of algal concentrations, even when algal concentration is much lower than the prediction by linear analysis in the RDA model. That is to say, spatial patterns result from the interaction of nonlinear terms. Moreover, patterns with different wavelength, amplitude and movement speed may coexist. The results obtained are consistent with the previous observation that self-organization allows mussels to persist with algal concentrations that would not permit survival of mussels in a homogeneous bed.

10. Spreading speeds for integro-difference systems

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Abstract: We study the following Kirchhoff problem

$$\left(a+\lambda\int_{\mathbb{R}^N}|\nabla u|^2+\lambda b\int_{\mathbb{R}^N}u^2\right)[-\Delta u+bu]=f(u),\quad \text{in } \mathbb{R}^N,$$

where $N\geqslant 3$, and a,b are positive constants, $\lambda\geqslant 0$ is a parameter. The existence of positive solutions to the above Kirchhoff type problem on $\mathbb{R}^N$ is proved by using variational methods, and the new result does not require usual compactness conditions. A cut-off functional and a Pohozaev type identity are utilized to obtain the bounded Palais-Smale sequences. This is joint work with Fuyi Li and Junping Shi.

11. Spreading speeds for integro-difference systems

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Abstract: In this talk, I will show some results on the principal eigenvalues of the noncompact operators and its applications for the spreading speeds for integro-difference systems.

12. Recent Progress on Gradient System of Phase Transition

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Abstract: Gradient system of phase transition has been studied over the past 35+ years by numerous authors. Many fascinating and important mathematical results and ideas have been also developed around this particular topic. Almost exclusively, these works are dealing with the case that phases being described by single-tons or a connected manifold. Phases transition problems with higher dimensional multiple components of phases can be used to model much complex physical phenomena, and mathematically more challenging. Here I shall describe some recent joint works with Xingbin Pan and Changyou Wang on phase transition problems with higher dimensional potential wells (phases).

13. Sharp Weyl-type formulas of the spectral functions for biharmonic Steklov eigenvalues

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Abstract: Let Ω be a bounded domain with C^2-smooth boundary in an n-dimensional oriented Riemannian manifold. It is well known that for the biharmonic equation $\Delta^2 u = 0$ in Ω with the condition $u = 0$ on $\partial\Omega$, there exists an infinite set u_k of biharmonic functions in Ω with positive eigenvalues λ_k satisfying $\Delta u_k + \lambda_k \frac{\partial u}{\partial \nu} = 0$ on $\partial\Omega$. In this talk, by a new method we establish the Weyl-type asymptotic formula for the counting function of the biharmonic Steklov eigenvalues λ_k. Furthermore, by explicitly calculating the principal symbols of pseudodifferential operators and by applying Hömander's spectral function theorem, we also obtain the Weyl-type asymptotic formulas with sharp remainder estimates in a smooth bounded domain.

14. Influence of the boundary geometry on the interface motion in a band domain

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Abstract:We study a curvature flow equation in a band domain with (almost) periodic undulating boundaries. First we give the definition and prove the existence of (almost) periodic traveling waves, then we study how the average speed of the (almost) periodic traveling wave depends on the geometry of the domain boundaries. More specifically, we consider the homogenization problem as the period of the boundary undulation tends to zero, and determine the homogenization limit of the average speed of traveling waves. Quite surprisingly, this homogenized speed depends only on the maximum opening angle of the domain boundary and no other geometrical features are relevant. Our analysis also shows that the boundary

undulation always lowers the speed of traveling waves, at least when the boundary bumps are small enough. This is a joint work with H. Matano and K.I. Nakamura.

15. Propagating terrace in 1D diffusion equations and reversed blow-up profiles in nonlinear heat equations

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Abstract: In this talk, I will discuss two problems of different nature in which the so-called "intersection-number argument" plays a key role in classifying the solution profiles.

The first problem is concerned with the front propagation in one-dimensional diffusion equations of the form

$$u_t = u_{xx} + f(x,u) \quad (x \in \mathbf{R}),$$

where f is a smooth function satisfying $f(x+L,u) \equiv f(x,u)$. We consider a large class of nonlinearities f including multistable ones. Our analysis reveals some new dynamics where the asymptotic profile of the solution is not characterized by a single front, but by a layer of several fronts traveling at different speeds, which we call a "propagating terrace". This is joint work with Thomas Giletti and Arnaud Ducrot.

The second problem is concerned with blow-up in nonlinear heat equations of the form

$$u_t = \Delta u + |u|^{p-1}u \quad \text{on} \quad \mathbf{R}^N,$$

where $N \geq 3$ and $p > p_S := \frac{N+2}{N-2}$ (Sobolev supercritical). We assume that the solution is radially symmetric. It is well known that solutions may blow up in finite time if $p > 1$. Furthermore, if $p > p_S$, there are cases in which solutions can be continued beyond the blow-up time in a certain weak sense. Such a case is called *incomplete blow-up*. In the case of incomplete blow-up, one can think of blow-up profiles as $t \nearrow T$ and as $t \searrow T$, where T denotes the blow-up time. The former has been well studied by using the rescaled energy functional (backward-rescaling for $t < T$). However, little was known for the latter, due mainly to the lack of good Lyapunov functional for the forward rescaling ($t > T$). What needs to be shown is the existence of the limit of a rescaled solution as $s \to -\infty$ (which corresponds to $t \searrow T$ in the normal coordinates). In this lecture I will show how to prove the existence of this limit by using the intersection number argument.

16. Recent results on some shallow water equations

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Abstract: In this talk, we shall introduce some recent progress on some shallow water equations. First of all, we consider a higher order shallow water equation, and obtain the local well-posedness of solutions for the Cauchy problem in Sobolev space. Under some

assumptions, the existence and uniqueness of the global solutions is established. Based some conditions, we also prove the development of singularities in finite time for the solutions and the weak solution for the equation. Secondly, a new model containing both the famous Camassa-Holm and Novikov equation is improved. We also establish the local well-posedness in a range of the Besov spaces and the precise blow-up scenario. Moreover, we prove that peakon solutions to the equation are global weak solutions. Finally, the continuation of solutions to the generalized Camassa-Holm equation beyond wave breaking is considered. A continuous semigroup of global conservative and dissipative solutions are obtained. We show that the solutions are conservative, in the sense that the total energy equals to a constant, for almost every time, while the solutions are dissipative, energy loss occurs through wave breaking.

17. Segregated and Synchronized Vector Solutions for Nonlinear Schrödinger Systems

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Abstract: In this talk, I talk the following nonlinear Schrödinger system in R^3

$$\begin{cases} -\Delta u + P(|x|)u = \mu|u|^2u + \beta v^2 u, & x \in R^3, \\ -\Delta v + Q(|x|)v = \nu|v|^2v + \beta u^2 v, & x \in R^3, \end{cases}$$

where $P(r)$ and $Q(r)$ are positive radial potentials, $\mu > 0, \nu > 0$ and $\beta \in R$ a coupling constant. This type of system arises in particular in models in Bose-Einstein condensates theory. We examine the effect of the nonlinear coupling to the solution structure. In the repulsive case we construct an unbounded sequence of non-radial positive vector solutions of segregated type and in the attractive case we construct an unbounded sequence of non-radial positive vector solutions of synchronized type. Depending upon the system being repulsive or attractive our results exhibit distinct characteristic features of vector solutions. This is a joint work with Professor Zhiqiang Wang.

18. A perturbation method up to boundary for Poisson equations

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Abstract: We adapt the perturbation method developed by Xu-Jia Wang up to boundary and prove a log-Lipschitz estimate for gradient of solutions to the Possion equation when the boundary value is in $C^{1,1}$ class. When the boundary value is in $C^{2,\alpha}$ class, we show that the perturbation method can provide a united one to prove the Schauder estimates up to the boundary when the nonhomogeneous term $f(x)$ is Dini continuous, Holder continuous and Lipschitz continuous. Also all of our results are local.

19. Exponential Stability of Large-Amplitude Traveling Fronts for Quasi-linear Relaxation Systems with Diffusion

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Abstract: In this talk, we study the stability of traveling front solutions for 2×2 quasi-linear relaxation systems with small diffusion rate. By applying geometric singular perturbation method, special Evans function estimates, detailed spectral analysis and C^0 semigroup theories, we prove that all the non-degenerate waves for semi-linear relaxation systems are locally exponentially stable in some exponentially weighted spaces. We also obtain the linear exponential stability of the non-degenerate waves for quasi-linear relaxation systems, where the wave strengths can be large.

20. Blow-up initial-boundary value problem for p-Laplacian parabolic equations with general absorption

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Abstract: In this talk, we investigate the p-Laplacian parabolic equation $u_t - \Delta_p u = -b(x,t)f(u)$ with blow-up initial and boundary values over a smooth bounded domain Ω of $\mathbb{R}^N$ with $N \geq 2$, where $\Delta_p u = \mathrm{div}(|\nabla u|^{p-2}\nabla u)$ with $p > 1$, and $f(u)$ is a function of regular variation at infinity. We study the existence and uniqueness of positive solutions, and their asymptotic behavior near the parabolic boundary. This is a joint work with Peter Y. H. Pang and Yujuan Chen.

21. Effective Boundary Conditions Resulting from Anisotropic and Optimally Aligned Coatings

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Abstract: Of concern is a thermally conducting body insulated by a thin anisotropically conducting coating. The coating is *optimally aligned* in the sense that the normal vector inside the coating is always an eigenvector of the thermal tensor. We study the effects of the coating by investigating the limiting behavior of solutions u of the heat equation with either Dirichlet or Neumann boundary condition imposed on the outer boundary of the coating, as the thickness of the coating shrinks to zero. In the two-dimensional case, we find the complete list of *effective boundary conditions* satisfied by the limit of u on the boundary of the uncoated body. This list contains not only the usual Dirichlet, Neumann and Robin boundary conditions, but also some new and even nonlocal ones involving the Dirichlet-to-Neumann mapping, the Hilbert transformation and the Laplace-Beltrami operator. We also prove that u converges to its limit in various norms that include the L^2, the Sobolev and

the Hölder ones. During the course of this study, we establish a Schauder theory for the regularity of weak solutions of general second order parabolic equations near an interface where the *transmission condition* is satisfied. This is a joint of work with Xinfu Chen and Cody Pond.

22. Competing effects of attraction and repulsion in chemotaxis

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Abstract: Most of past studies on chemotaxis models deal with attraction and repulsion separately. But in most biological processes (or experiments), the repulsive process usually follows the attractive process for balance in order to accomplish some biological objects. Hence an attraction and repulsion chemotaxis model will be more realistic than a sole attraction or repulsion chemotaxis model in this scenario. In this talk, we shall present the first mathematical results on an attraction-repulsion chemotaxis model and show the interplay of these two opposed biological processes. Some numerical simulations will be shown and various open questions will be presented.

23. Asymptotic Stability of Travelling Fronts with Algebraic Spacial Decay for Autocatalytic Reaction Systems

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Abstract: This is a joint work with Yi Li, University of Iowa and Wright State University. Consider the following autocatalytic chemical reaction system

$$\begin{cases} u_t = u_{xx} - u^q v^p, \\ v_t = dv_{xx} + u^q v^p. \end{cases}$$

For $p \geq 1$, $q \geq 1$ and $d > 0$, it is known that there exists a critical speed $c^*(p, q, d)$ such that for any $c \geq c^*(p, q)$ there exist travelling front solutions $(u(x-ct), v(x-ct))$ connecting $(0, 1)$ and $(1, 0)$. For the cases $p > 1$ or $q > 1$, the travelling waves with noncritical speed decay algebraically in space at $+\infty$ or $-\infty$.

In this talk we shall be more interested in the asymptotic stability of the wave fronts with noncritical speeds and with algebraic spacial decay for $p > 1$ and $q \geq 1$. We shall talk about our recent works on the linear and nonlinear asymptotic stability of the waves in some weighted spaces for the system when the diffusion rates are close, and we shall talk about our abstract results on the existence and analyticity of Evans function for the more general ODE systems with slow algebraic decaying coefficients.

24. On mixed-type equation and degeneracy

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Abstract: In this talk, I will discuss some recent progress on the existence of smooth transonic flows in a nozzle with variable sections. The flow will be governed by the well-known steady compressible full potential flow equation which is a degenerate elliptic-hyperbolic equation for such flows. We will discuss properties of smooth transonic flows in a de Laval nozzle and give the first general existence of such solutions with physically reasonable boundary conditions in the 2-dimensional space.

25. Regularity of solution for an elliptic-parabolic system arising from a microwave heating model

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Abstract: In this paper we study regularity of weak solution for an elliptic-parabolic system arising from the microwave heating model. One of the challenges is that the elliptic system is also degenerate. By exploiting the decomposition of functions and Morrey-John-Nirenberg-Campanato type of estimates, we are able to show that the solution is actually regular. Some applications are also presented in the paper.

26. Traveling water waves with compactly supported vorticity

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Abstract: We consider the water wave problem – the free boundary problem of the Euler equation – and construct small traveling wave solutions with vorticity based on a bifurcation method. The vorticity of these solutions are supported in a small domain away from the water surface. This is a joint work with Jalal Shatah and Sam Walsh.

27. Critical exponent for the semilinear wave equation with time-dependent damping

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Abstract: We consider the Cauchy problem for the semilinear wave equation with time-

dependent damping

$$\begin{cases} u_{tt} - \Delta u + b(t)u_t = |u|^\rho, & (t,x) \in \mathbb{R}^+ \times \mathbb{R}^N \\ (u, u_t)(0,x) = (u_0, u_1)(x), & x \in \mathbb{R}^N. \end{cases} \tag{$*$}$$

When $b(t) = b_0(t+1)^{-\beta}$ with $b_0 > 0$ and $-1 < \beta < 1$ and $\int_{\mathbf{R}^N} u_i(x)\,dx > 0\,(i = 0, 1)$, we show that the time-global solution of $(*)$ does not exist provided that $1 < \rho \le \rho_F(N) := 1 + 2/N$ (Fujita exponent). On the other hand, when

$$\rho_F(N) < \rho < \frac{N+2}{[N-2]_+} := \begin{cases} \infty & (N = 1, 2), \\ (N+2)/(N-2) & (N \ge 3), \end{cases}$$

the small data global existence of solution has been recently proved in [K. Nishihara, Asymptotic behavior of solutions to the semilinear wave equation with time-dependent damping, to appear in Tokyo J. Math.] provided that $0 \le \beta < 1$. We can prove the small data global existence even if $-1 < \beta < 0$. Thus, we conclude that the Fujita exponent $\rho_F(N)$ is still critical even in the time-dependent damping case. For the proofs we apply the weighted energy method and the method of test functions by [Qi S. Zhang, A blow-up result for a nonlinear wave equation with damping: The critical case, C. R. Acad. Sci. Paris **333** (2001), 109-114].

28. On Phase-Separation Model: Asymptotics and Qualitative Properties

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Abstract: Here we study bound state solutions of a class of two-component nonlinear elliptic systems with a large parameter tending to infinity. The large parameter giving strong inter-component repulsion induces phase separation and forms segregated nodal domains divided by an interface. To see the profile of bound state solutions near the interface, we prove the uniform Lipschitz continuity of bound state solutions when the spatial dimension $N = 1$. Furthermore, we show the blow-up nonlinear elliptic system having unbounded solutions with symmetry and monotonicity. This is joint work with Henri Berestycki, Tai-Chia Lin and Juncheng Wei.

29. Fujita phenomena in coupled system of pseudo-parabolic equations

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Abstract: This talk deals with the Fujita phenomena occurring in a coupled system modeling heat conducting with dispersive and dissipative mechanisms in a two-component non-simple mixture. In particular, we determine the second critical exponent to characterize the critical space-decay rate of initial data in the co-existence region of global and non-global solutions. Moreover, we show the time-decay profiles for the global solutions. Although the above asymptotic properties of solutions are similar to those for general semilinear heat system, we have to use distinctive techniques to treat the influence from the additional viscosity terms

of the highest order. To fix the non-global solutions, we exploit the test function method, in stead of the general Kaplan method for heat systems. To obtain the global solutions, we apply the L^p-L^q technique to establish some uniform L^m time-decay estimates. Based on a suitable classification for the nonlinear parameters and the initial data, various L^m time-decay estimates in the procedure enable us to arrive at the time-decay profiles of solutions to the system. It is mentioned that the general scaling method for parabolic problems heavily relies on regularizing effect to establish the compactness of approximating solutions, which cannot be realized here due to absence of the smooth effect in the present model.

30. A multidimensional free boundary problem modeling tumor growth

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Abstract: In this talk, we study a multidimensional free boundary problem modeling the growth of tumors with fluid-like tissue. The model includes two diffusion equations describing the concentration of nutrients and inhibitors, and a Stokes equation for the fluid velocity and internal pressure. We make rigorous mathematical analysis for this free boundary problem and give its interesting biological implications.

31. $C^{1,\alpha}$ Regularity of weak solutions for a class of quasilinear elliptic equations

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Abstract: In this work we obtain the interior $C^{1,\alpha}$ regularity of weak solutions for a class of quasilinear elliptic equations, including the p-Laplace equation.