SITE Research Center online event from May 30 to June 2, 2022 on

Long Time Behavior and Singularity Formation in PDEs — Part V

(the talk times are given in Gulf Standard Time)

Monday, May 30

1.15 pm: Opening remarks by **Sehamuddin Galadari**, Senior Vice Provost of Research; Managing Director, Research Institute; Professor of Biology, New York University, Abu Dhabi

1.20 - 2.20 pm: **Sylvia Serfaty**

- Title: Mean-field limits for singular flows
- Abstract: We discuss the derivation of PDEs as limits as N tends to infinity of the dynamics of N points for a certain class of Riesz-type singular pair interactions. The method is based on studying the time evolution of a certain "modulated energy" and on proving a functional inequality relating certain "commutators" to the modulated energy. When additive noise is added, in dimension at least 3 a uniform in time convergence can even be obtained. Based on joint works with Hung Nguyen, Matthew Rosenzweig.

2.30 – 3.30 pm: **Michele Coti Zelati**

- Title: Exponential mixing for random flows
- Abstract: We consider random dynamical systems driven by noise that is absolutely continuous with respect to the Lebesgue measure, and exhibit sufficient conditions that imply exponential mixing. As a corollary, we show that the so-called Pierrehumbert model, consisting of alternating shear flows with randomized phases, is exponentially mixing.

5.30 – 6.30 pm: **Avraham Soffer**

- Title: The Asymptotic States of Nonlinear Dispersive Equations with Large Initial Data and General Interactions
- Abstract: I will describe a new approach to scattering theory, which allows the analysis of interaction terms which are linear and space-time dependent, and nonlinear terms as well. This is based on deriving (exterior) propagation estimates for such equations, which micro-localize the asymptotic states as time goes to infinity. In particular, the free part of the solution concentrates on the propagation set (x=vt), and the localized leftover is characterized in the phase-space as well. The NLS with radial data in three dimensions is considered, and it is shown that besides the free asymptotic wave, in general, the localized part is smooth, and is localized in the region where |x|^2 is less than t. Furthermore, the localized part has a massive core and possibly a halo which may be a self-similar solution. This work is joint with Baoping Liu. This is

then followed by new results on the non-radial case and Klein-Gordon equations (Joint works with Xiaoxu Wu)

Tuesday, May 31

1.15 – 2.15 pm: **Matthew R. I. Schrecker**

- Title: Self-similar gravitational collapse for Newtonian stars
- Abstract: The Euler-Poisson equations give the classical model of a self-gravitating star under Newtonian gravity. It is widely expected that, in certain regimes, initially smooth initial data may give rise to blow-up solutions, corresponding to the collapse of a star under its own gravity. In this talk, I will present recent work with Yan Guo, Mahir Hadzic and Juhi Jang that demonstrates the existence of smooth, radially symmetric, self-similar blow-up solutions for this problem. At the heart of the analysis is the presence of a sonic point, a singularity in the self-similar model that poses serious analytical challenges in the search for a smooth solution.

2.30 – 3.30 pm: **Gregory Seregin**

- Title: Long time behaviour and local regularity for solutions to the Navier-Stokes equations
- Abstract: We shall discuss the problem of local regularity for solutions to the Navier-Stokes equations under certain scale-invariant conditions. Using zooming and duality, we reduce it to the problem of long time behaviour of a certain Stokes equations with a drift. This is in part a joint work with M. Schonbek.

5.30– 6.30 pm: **Zhiyuan Zhang**

- Title: Stability of solitary waves of the NLS equation
- Abstract: We consider the asymptotic stability of the solitary waves of 1D NLS equations, under the assumption that the linearized operator is generic (no endpoint resonance) and has no internal modes. Moreover, we also consider the 1D nonlinear Klein-Gordon equation with a potential, and give a result on small data existence. The method of analysis is based on the distorted Fourier transform. This is joint work with P. Germain and F. Pusateri.

Wednesday, June 1

1.15 – 2.15 pm: **Klaus Widmayer**

- Title: On the stability of a point charge for the Vlasov-Poisson system
- Abstract: A Dirac mass is a particularly simple yet relevant equilibrium of the (repulsive) Vlasov-Poisson equations. This talk addresses the question of its stability in the repulsive setting: we capture the precise asymptotic dynamics of solutions which start as small, smooth and suitably localized perturbations of a point charge. Our analysis builds on the Hamiltonian/symplectic structure of the equations, and makes use of an exact integration of the linearized equation through angle-action coordinates. This allows us to obtain optimal decay estimates and reveals a modified scattering dynamic. This is joint work with Jiaqi Yang (ICERM) and Benoit Pausader (Brown University).

2.30 – 3.30 pm: **Jaemin Park**

- Title: Existence of non-radial stationary solutions to the 2D Euler equation
- Abstract: In this talk, we study stationary solutions to the 2D incompressible Euler equations in the whole plane. It is well-known that any radial vorticity is stationary. For compactly supported vorticity, it is more difficult to see whether a stationary solution has to be radial. In the case where the vorticity is non-negative, it has been shown that any stationary solution has be radial. By allowing the vorticity to change the sign, we prove that there exist non-radial stationary patch-type solutions. We construct patch-type solutions whose kinetic energy is infinite or finite. For the finite energy case, it turns out that a construction of a stationary solution with compactly supported velocity is possible.

5.30 – 6.30 pm: **Robert Strain**

- Title: On the 2D fully nonlinear Peskin problem
- Abstract: The Peskin problem models the dynamics of a closed elastic string immersed in an incompressible 2D stokes fluid. This set of equations was proposed as a simplified model to study blood flow through heart valves. The immersed boundary formulation of this problem has proven very useful in particular giving rise to the immersed boundary method in numerical analysis. In a joint work with Stephen Cameron, we consider the general case of a fully non-linear tension law. We prove local wellposedness for arbitrary initial data in the scaling critical Besov space \dot{B}^{3/2}_{2,1}, and the high order smoothing effects for the solution.

Thursday, January 2

1.15 – 2.15 pm: **Tak Kwong WONG**

- Title: Regularity structure, global-in-time existence and uniqueness of energy conservative solutions to the Hunter-Saxton equation
- Abstract: The Hunter-Saxton equation is an integrable equation in one spatial dimension, and can be used to study the nonlinear instability in the director field of a nematic liquid. In this talk, we will discuss the regularity structure, global-in-time existence and uniqueness of energy conservative solutions to the Hunter-Saxton equation. In particular, singularities for the energy measure may only appear at at most countably many times, and are completely determined by the absolutely continuous part of initial energy measure. The temporal and spatial locations of singularities are explicitly determined by the initial data as well. The analysis is based on using the method of characteristics in a generalized framework that consists of the evolutions of solution to the Hunter-Saxton equation and the energy measure. This is a joint work with Yu Gao and Hao Liu.

2.30 – 3.30 pm: **Christophe Prange**

- Title: Concentration and quantitative regularity for the Navier-Stokes equations
- Abstract: In this talk I will show concentration phenomena near potential singularities of the three-dimensional Navier-Stokes equations. I will also investigate the connection between

concentration estimates and quantitative regularity. This is joint work with Tobias Barker (University of Bath).