Asymptotic flocking dynamics of Cucker-Smale particles immersed in compressible fluids

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Abstract: We propose a coupled system for the interaction between CuckerSmale flocking particles and viscous compressible fluids, and present a global existence theory and time-asymptotic behavior for the proposed model in the spatial periodic domain T^3 . Our model consists of the kinetic Cucker-Smale model for flocking particles and the isentropic compressible Navier-Stokes equations for fluids, and these two models are coupled through a drag force, which is responsible for the asymptotic alignment between particles and fluid. For the asymptotic flocking behavior, we explicitly construct a Lyapunov functional measuring the deviation from the asymptotic flocking states. For a large viscosity and small initial data, we show that the velocities of Cucker-Smale particles and fluids are asymptotically aligned to the common velocity.

Coworkers: Young-Pil Choi, Seung-Yeal Ha, Moon-Jin Kang

On Flocks Influenced by Closest Neighbors

Jiu-Gang Dong

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Abstract: We prove, both for continuous time and discrete time, results establishing convergence to flocking in a model in which each agent is influenced by only a few closest neighbors. We show unconditional convergence to flocking when this number of closest neighbors is at least half of the population and, otherwise, conditional convergence. That is, convergence to flocking provided the initial positions and velocities satisfy an explicit constraint. We also show that the proportion of neighbors necessary for unconditional convergence, one half, is sharp. This is a joint work with Prof. Felipe Cucker.

Mathematical challenges for classical and quantum synchronization

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Abstract: Synchronization of oscillators denotes a phenomenon for the adjustment of rhythms among weakly coupled oscillators, and one of collective modes appearing in oscillatory complex systems such as ensembles of Josepson junctions array, pacemaker cells and fireflies etc. In this talk, I will briefly report the recent progress for synchronization and discuss some challenging open problems arising from synchronization via the Kuramoto and Lohe models.

Some mathematical results on the Cucker-Smale model and related models

Chunyin Jin

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Abstract: Cucker-Smale model is a simplified model used for describing flocking phenomenon in nature. In this talk, we will show the bi-cluster flocking phenomenon for the short-ranged Cucker-Smale model under some conditions. As for the kinetic Cucker-Smale model with the cut-off interaction function, we will prove the existence of the weak solutions by using weak convergence method.

Particle-path analysis on Kuramoto oscillators under additive noise

Dongnam Ko

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Abstract: From Huygens' observation on two synchronous pendulum clocks in the middle of 17th century, its rigorous studies have been started only in several decades ago by two pioneers Winfree and Kuramoto. The Kuramoto model is extensively studied because of its good properties, such as conservation of total phase velocity and existence of analytic potential. In this talk, we consider the Kuramoto model with additive noise, which is given by Brownian motion on oscillators' phases. The main concern is to present a sufficient framework which leads to the synchronization under noise. In the deterministic Kuramoto model, the synchronization phenomenon is observed by particle's trajectory which goes to a stable equilibrium point. Due to the additive noise, a sink is no longer stable, and the particle-path analysis can be described only under some probability. With a short introduction on the potential analysis from the large-deviation theory, we will see how Lyapunov functional approach works on particle-path analysis for the stochastic Kuramoto oscillators.

CASCADE FLOCKING WITH FREE-WILL AND WEAK FLOCKING BEHAVIOR

Le Li (National University of Defense Technology)

Abstract: In this talk we will introduce a self-organized system with a hierarchy structure toallow multiple leaders in the highest rank, and with free-will. In the model, weuse both Cucker-Smale and Motsch-Tadmor functions for the pair ininfluence of agents, and we derive suffcient conditions for such a system to converge to aflock, where agents ultimately move in the same velocity. Also， the weak flocking is introduced which means thatthe agents do not need have the same veloctities to keep together at any time $t > 0$. This is the biggest difference with the flocking behavior. We propose a weak flocking model with two agentsand study two different mechanisms for this model. Otherwise, we also consider a system with N agents. Under the weak link mechanism, the system can keep weak flocking.

A Rotating Consensus Algorithm for Second-Order Dynamics

Xiang Li (N**atio**nal University of Defense Technology)

Abstract: Collective behavior is a common natural phenomenon, such as fish swimming, birds flocking and agents synchronizing. Collective theory is an important branch of complex systems and shows various applications in the field of economic, military and management. This paper investigates the collective rotating motions of a team of vehicles in three dimensions by introducing a rotation matrix to an existing algorithm for double-integrator dynamics. The result is that if the topology structure, the rotation angle, and the damping gain satisfy some conditions, the system will finally achieve asymptotic consensus or rotating consensus.

On the synchronization of coupled oscillators with frustration

Zhuchun Li

Department of Mathematics, Harbin Institute of Technology

Abstract: In this talk we will briefly present some rigorous results in the synchronization of coupled oscillators with frustrations, including both first-order and second-order models.

Adaptive Elimination of Synchronization in Coupled Oscillators

Wei Lin (ISTBI and School of Mathematical Sciences, Fudan University)

Abstract: In this talk, we introduce an adaptive control technique with a feedback delay to achieve synchronization elimination in a large population of coupled and synchronized oscillators. We validate the feasibility of this technique not only in the coupled Kuramoto's oscillators with unimodal or bimodal distribution of natural frequencies, but also in representative analog models of neuronal networks, e.g. the FitzHugh-Nagumo spiking oscillators and the Hindmarsh-Rose bursting oscillators. More significantly, we discover how the exact form of natural frequency distribution influences the performance of this technique with a feedback delay. It is expected that the developed technique as well as the physical discoveries could be potentially useful for designing automatic controllers, e.g. deep brain stimulators, to remedy some synchronization-induced mental disorders including Parkinson disease and epilepsy.

Multi-cluster flocking behavior of the hierarchical Cucker-Smale model

Lining Ru

Department of Mathematics, Harbin Institute of Technology

Abstract: In this report, we investigate the multi-cluster flocking behavior of the hierarchical Cucker-Smale model parameterized by a constant β measuring the strength of the interaction between agents. The previous studies showed that when $0\leq\beta<1/2$ unconditional flocking would occur, while for $\beta\geq1/2$ conditional flocking would occur provided the initial data satisfy some given conditions. We will show in this report that, when $\beta=1/2$, unconditional flocking would occur for the model, while for $\beta>1/2$, we give a complete understanding for the asymptotic multi-cluster formation when the initial positions and velocities have the ordering relations: by computing the initial data we can specify how many clusters emerge and which agents are in the same cluster.

Keywords: hierarchical Cucker-Smale model; multi-cluster flocking; l_1-norm.

L^2-contraction of large planar shock waves for multi-dimensional scalar viscous conservation laws

Yi Wang

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Abstract: We consider L^2 contraction of large viscous shock wave for the multi-dimensional scalar viscous conservation laws, up to a suitable shift. The shift function depends on both time and space variable, which solves a parabolic equation with inhomogeneous coefficient reflecting the perturbation. We consider a suitably small L^2-perturbation around a viscous planar shock

wave of arbitrarily large strength. However, we do not impose any conditions on the anti-derivative variables of the perturbation around shock profile. More precisely, it is proved that if the initial perturbation around the viscous shock wave is suitably small in L^2 norm, then L^2 contraction holds true for the viscous shock wave up to a shift function which may depend on the temporal and spatial variables. Moreover, as the time t tends to infinity, the L^2 contraction holds true up to a time-dependent shift function. In particular, if we choose some special initial perturbation, then we can prove a L^2-convergence of perturbation towards shock profile up to a time-dependent shift. It is a joint work with Alexis Vasseur(University of Texas at Austin, USA) and Moon-Jin Kang(University of Texas at Austin, USA).

Emergent dynamics of the Cucker-Smale particles under the effects of a random communications and incompressible fluids

Qinghua Xiao
Wuhan Institute of Physics and Mathematics, Chinese Academy of Science

Abstract：We study the dynamics of infinitely many Cucker-Smale(C-S) flocking particles under the interplay of a random communication and incompressible fluid. For the dynamics of ensemble of flocking particles, we use the kinetic Cucker-Smale-Fokker-Planck (CS-FP) equation with a degenerate diffusion coefficient, whereas for the fluid part, we use the incompressible Navier-Stokes(N-S) equations. These two subsystems are coupled via the drag force. For this coupled model, we present global existence of weak and strong solutions in $\bbr^d $ $(d=2 or 3)$. Under extra regularity assumptions of initial data, the unique solvability of strong solutions is also established in $\bbr^2$. In a large coupling regime and a periodic spatial domain, we show that the velocities of C-S particles and fluids are asymptotically aligned to constant velocities in a two-dimensional periodic spatial domain $\bbt^2:=\bbr^2/\bbz^2$.

Some Thoughts on Distributed Cooperative Control in Multi-agent Systems

Wenwu Yu(Eastsouth University)

Abstract: In this talk, the multi-agent collective behaviors and some of their potential applications are briefly reviewed. In particular, the consensus problem in multi-agent systems with first-order, second-order, and higher-order dynamics is investigated in details. Then, some extensions and recent progress for general protocols in multi-agent systems will be given. Furthermore, the new directions and challenges for the research work on this topic will be discussed.

Ellipsoidal BGK model for polyatomic particles

Seok-Bae Yun (Sungkyunkwan University, Korea)

Abstract: In this talk, we present our recent results on the polyatomic ellipsoidal BGK model, which is a relaxation type kinetic model describing the time evolution of phase space distribution of polyatomic particles.

Uniform stability and mean-field limit of flocking model

Xiongtao Zhang(Seoul National University)

Abstract: In this paper, we present uniform stability estimates for flocking model with respect to the initial data. In this study, we show that the mixed Lebesgue norm between two solutions is uniformly bounded by the same mixed Lebesgue norm between two initial data with the same total momentum. As a direct application of the uniform stability, we obtain the uniform-in-time mean-field limit from the particle model to the kinetic model in the Wasserstein metric.

Emergence dynamics for Cucker-Smale flocking particles

Yinglong Zhang(Seoul National University)

Abstract: Merging and separation of flocking groups are often observed in our natural complex systems. In this talk, we introduce the Cucker-Smale particle model to model such merging and separation phenomena, and talk about the emergence of global and local flocking for this model.