# ICCM 2020 Online Series of Conferences on Applied Math

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## Section 1: June 2020

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| **Time:** June 4, 8:30-9:30 AM (Beijing time) Lecture No. 20200604-01 | | | |
| **Lecture website (zoom):** https://us02web.zoom.us/j/89536670985<br>**ID:** 89536670985 **Password:** 20200604 | | | |
| **Speaker** | Xianfeng Gu | **Affiliation** | Stony Brook University, USA |
| **Title:** A geometric understanding of deep learning | | | |
| **Abstract:** This work introduces an optimal transportation (OT) view of generative adversarial networks (GANs). Natural datasets have intrinsic patterns, which can be summarized as the manifold distribution principle: the distribution of a class of data is close to a low-dimensional manifold. GANs mainly accomplish two tasks: manifold learning and probability distribution transformation. The latter can be carried out using the classical OT method. From the OT perspective, the generator computes the OT map, while the discriminator computes the Wasserstein distance between the generated data distribution and the real data distribution; both can be reduced to a convex geometric optimization process. Furthermore, OT theory discovers the intrinsic collaborative—instead of competitive—relation between the generator and the discriminator, and the fundamental reason for mode collapse. We also propose a novel generative model, which uses an autoencoder (AE) for manifold learning and OT map for probability distribution transformation. This AE–OT model improves the theoretical rigor and transparency, as well as the computational stability and efficiency; in particular, it eliminates the mode collapse. The experimental results validate our hypothesis, and demonstrate the advantages of our proposed model. | | | |
| **Short Bio:** Dr. Xianfeng Gu got his bachelor from Tsinghua university, PhD in computer science from Harvard university, supervised by the Fields medalist, Prof. Shing-Tung Yau. Currently, Dr. Gu is a New York State Empire Innovation Professor in the Computer Science Department, Stony Brook university. Dr. Gu's research focuses on applying modern geometry in engineering and medicine fields. Together with Prof. Shing-Tung Yau, Dr. Gu and other collaborators have founded an interdisciplinary field: Computational Conformal Geometry. Dr. Gu has won NSF Career award, Morningside Gold medal in applied Mathematics. | | | |

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| **Time:** June 11, 8:30-9:30 AM (Beijing time) Lecture No. 20200611-02 | | | |
| **Lecture website (zoom):** https://us02web.zoom.us/j/84417517383<br>**ID:** 84417517383 **Password:** 20200611 | | | |
| **Speaker** | Shuang Miao | **Affiliation** | Wuhan University, China |
| **Title:** On the free boundary hard phase fluid in Minkowski space | | | |
| **Abstract:** I will discuss a recent work on the free boundary hard phase fluid model with Minkowski background. The hard phase model is an idealized model for a relativistic fluid where the sound speed approaches the speed of light. This work consists of two results: First, we prove the well-posedness of this model in Sobolev spaces. Second, we give a rigorous justification of the non-relativistic limit for this model as the speed of light approaches infinity. This is joint work with Sohrab Shahshahani and Sijue Wu. | | | |
| **Short Bio:** Shuang Miao is a professor at Wuhan University. His main research interests lie in the singularity formation for nonlinear wave equations and long time behavior for free boundary problems in inviscid fluids. | | | |

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| **Time:** June 18, 8:30-9:30 AM (Beijing time) Lecture No. 20200618-03 | | | |
| **Lecture website (zoom):** https://us02web.zoom.us/j/86901726807<br>**ID:** 86901726807 **Password:** 20200618 | | | |
| **Speaker** | Dong Liang | **Affiliation** | Shenzhen Institutes of Advanced Technology, Chinese Academy of Sciences, China |
| **Title:** Fast magnetic resonance imaging: theory, technique and application | | | |
| **Abstract:** Magnetic resonance imaging (MRI) has become one of the most important medical revolutions and has played a significant role in modern medical imaging based diagnosis and therapy. However, the intrinsic relatively slow data acquisition has limited its applications largely. Usually, acquiring less data is an important strategy for accelerating MRI, with the proportional relationship between the number of acquired data and scanning time. However, less acquisition usually results in aliasing artifacts in reconstructions. Under this circumstance, image reconstruction problem becomes an ill-conditioned inverse problem. In this talk, we will provide an overview of the theory for fast MRI, some techniques we developed and their applications in accelerating MR imaging. | | | |
| **Short Bio:** Dr. Dong Liang is a Full Professor of Biomedical Engineering at Shenzhen Institutes of Advanced Technology (SIAT), Chinese Academy of Sciences (CAS). He is the Director of Research center for Artificial Intelligence in Medicine and Deputy Director of Research center for Biomedical Imaging, SIAT. Dr. Liang's research has focused on high-speed magnetic resonance imaging. He has published over 100 peer-reviewed papers and holds 3 U.S. patents and 30 China patents. His research has been well funded by state agencies, including NSF of China and The Ministry of Science and Technology of China, province agencies, and CAS. He received First prize in the BME award from the Chinese Society of Biomedical Engineering in 2019. He currently serves on the Editorial Board of Magnetic Resonance in Medicine and is an Associate Editor of the IEEE Transactions on Medical Imaging. He is a senior member of IEEE and is an elected member of IEEE Computational Imaging Technical Committee. | | | |

| **Time:** June 25, 15:30-16:30 (Beijing time) Lecture No. 20200625-04 | | | |
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| **Lecture website (zoom):** https://us02web.zoom.us/j/84580522524<br>**ID:** 84580522524 **Password:** 20200625 | | | |
| **Speaker** | Mourad Sini | **Affiliation** | RICAM Austrian Academy of Sciences, Austria |
| **Title:** Mathematical analysis of the photo-acoustic imaging modality using dielectric nanoparticles as contrast agents | | | |

**Abstract:** We will discuss our recent results on the mathematical analysis of the imaging modalities using injected highly contrasting small agents as the acoustic imaging, optical imaging and photo-acoustic imaging. It is known that without using such contrast agents, these imaging modalities are highly instable. However, using them shows improvement of the stability of the reconstruction, at least for benign anomalies, see for instance [1] and [2].

Our goal is to understand and mathematically quantify these findings by providing reconstruction formulas linking the corresponding measured data, of each modality, to the desired parameters of the model.

To show this, we will mainly focus on the photo-acoustic imaging modality using dielectric nanoparticles as contrast agents. The main argument in our analysis here is that these dielectric nanoparticles resonate at certain, computable, frequencies. Exciting the medium with propagating incident waves at frequencies close to such resonances creates local spots, around the injected nanoparticles, and enhance the measured fields. This feature is used to extract the unknown parameters of the model from the remotely measured data.

We will also discuss the acoustic or /and the optical imaging modalities using the corresponding contrasting agents (i.e. bubbles and nanoparticles respectively). Parts of the results presented in this talk can be found in the preprints [3] and [4].

[1] S. Qin, C. F. Caskey and K. W. Ferrara. Ultrasound contrast microbubbles in imaging and therapy: physical principles and engineering. Phys Med Biol. (2009).

[2]. W. Li and X. Chen, Gold nanoparticles for photoacoustic imaging, Nanomedicine (Lond.) 10(2), 2015.

[3]. A. Ghandriche and M. Sini. Mathematical Analysis of the Photo-acoustic imaging modality using resonating dielectric nanoparticles: The 2D TM-model. arXiv:2003.03162

[4]. A. Dabrowski, A. Ghandriche and M. Sini, Mathematical analysis of the acoustic imaging modality using bubbles as contrast agents at nearly resonating frequencies. arXiv:2004.07808

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**Short Bio:** Mourad Sini received his PhD degree from University of Provence, France, in 2002. Then he moved to Hokkaido University, Japan, where he worked during the two years 2003-2005 as a postdoc fellow of the Japanese Society for the Promotion of Sciences (JSPS). He spent the academic year 2005-2006 as a visiting professor at Yonsei University in Seoul, Korea. Since 2006, he joined the Radon Institute, RICAM, of the Austrian Academy of Sciences where he is affiliated as a senior fellow. Mourad Sini is an applied mathematician working in inverse problems, mathematical imaging and material sciences.