PiAI Seminar Series: Physics informed AI in Plasma Science
10:00-11:00, 13 June 2022 (CET)
17:00-18:00, 13 June 2022 (JST)
Web Seminar

Bayesian uncertainty quantification of physical models and its engineering applications

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"All models are wrong but some are useful," said George Box. The famous British statistician implied that all models would have some level of uncertainty when trying to represent a phenomenon. The missing puzzle could be due to limitation of measurement accuracy, incomplete understanding of physics, insufficient computation resources, etc. Bayesian inference is a modeling framework that captures all the uncertainties through probability distributions and propagates them based on rules in probability logics during prediction or decision-making using the "incorrect" models. There are typically two important aspects of Bayesian inference: (1) imposing realistic assumptions to stochastic models used in the inference, and (2) designing a tractable algorithm to handle the calculus of probability functions. Discussions in this presentation will be focusing on the first aspect. I will begin with a brief introduction of Bayesian inference using examples from different engineering problems. Then, I will expand the discussion to probabilistic modeling of complex data structures, which typically involves the use of hierarchical Bayesian models. I will share some learned lessons about the influence of selected stochastic models on uncertainty quantification and the final decision-making from applications of hierarchical models to engineering problems, such as calibration of molecular dynamics simulation and prediction of soil properties' correlations.