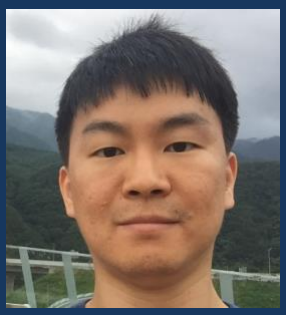
Department of Applied and Computational Mathematics and Statistics Colloquium



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Astronomical Time Delay Estimation via a Repelling-Attracting Metropolis Algorithm

I introduce an astronomical time delay estimation problem and a new Markov chain Monte Carlo method. The gravitational field of a galaxy can act as a lens and deflect the light emitted by a more distant object such as a quasar (quasi-stellar object). Strong gravitational lensing causes multiple images of the same quasar to appear in the sky. Since the light in each gravitationally lensed image traverses a different path length from the quasar to the Earth, fluctuations in the source brightness are observed in the several images at different times. The time delay between these fluctuations can be used to constrain cosmological parameters and can be inferred from the time series of brightness data. To estimate the time delay, we construct a model based on a state-space representation for irregularly observed time series generated by a latent continuous-time Ornstein–Uhlenbeck process.

However, the time delay estimation often suffers from multimodality. To handle this, we propose the repelling-attracting Metropolis (RAM) algorithm that maintains the simple-to-implement nature of the Metropolis algorithm, but is more likely to jump between modes. The RAM algorithm is a Metropolis-Hastings algorithm with a proposal that consists of a downhill move in density that aims to make local modes repelling, followed by an uphill move in density that aims to make local modes attracting. This down-up movement in density increases the probability of a proposed move to a different mode. Because the acceptance probability of the proposal involves a ratio of intractable integrals, we introduce an auxiliary variable which creates a term in the acceptance probability that cancels with the intractable ratio.

Tuesday, December 19, 2017
4:30 PM – 5:30 PM
127 Hayes-Healy Center

Colloquium Tea 4:00 PM to 4:30 PM 154 Hurley Hall