2023 LIAM-NSERC/Mitacs/Sanofi Alliance Summer Symposium Series
Dynamical Systems with Applications

Lecture # 2

Spatiotemporal Dynamics in Epidemic Models with Levy Flights: A Fractional Diffusion Approach

Lecture By

Professor Shigui Ruan

Dr. Shigui Ruan received his Ph.D. in Applied Mathematics from the University of Alberta in 1992. He was a Junior Fellow at the Fields Institute for Research in Mathematical Sciences in 1992-1993 and a Post-doctoral Fellow at McMaster University in 1993-1994. After being an Assistant and Associate Professor at Dalhousie University from 1994 to 2002, he joined the Department of Mathematics at the University of Miami in 2002 where he is now a Full Professor and Cooper Fellow. He is interested in Differential Equations, Dynamical Systems, and Mathematical Biology and published over 200 papers in both scientific and mathematical journals including PNAS, Lancet Infect Dis, Memoirs Amer Math Soc, Trans Amer Math Soc, SIAM J Math Anal, SIAM J Appl Math, J Differential Equations, J Funct Anal, J Math Pures Appl, Math Ann, etc. His research has been supported by the NSERC, NIH, NSF, CDC, and NNSFC. He was a Thomson Reuters Highly Cited Researcher in 2014 and 2015. He serves on the editorial boards of several journals including the Bulletin of Mathematical Biology, Infectious Disease Modeling, Journal of Mathematical Biology, Mathematical Biosciences, Nonlinear Analysis – Real World Applications, etc.

Abstract

Recent field and experimental studies show that mobility patterns for humans exhibit scale-free nonlocal dynamics with heavy-tailed distributions characterized by Levy flights. To study the long-range geographical spread of infectious diseases, in this paper we propose a susceptible-infectious-susceptible epidemic model with Levy flights in which the dispersal of susceptible and infectious individuals follows a heavy-tailed jump distribution. Owing to the fractional diffusion described by a spectral fractional Neumann Laplacian, the nonlocal diffusion model can be used to address the spatiotemporal dynamics driven by the nonlocal dispersal. The primary focuses are on the existence and stability of disease-free and endemic equilibria and the impact of dispersal rate and fractional power on spatial profiles of these equilibria. A variational characterization of the basic reproduction number R0 is obtained and its dependence on the dispersal rate and fractional power is also examined. Then R0 is utilized to investigate the effects of spatial heterogeneity on the transmission dynamics. It is shown that R0 serves as a threshold for determining the existence and nonexistence of an epidemic equilibrium as well as the stabilities of the disease-free and endemic equilibria. In particular, for low-risk regions, both the dispersal rate and fractional power play a critical role and are capable of altering the threshold value. Numerical simulations were performed to illustrate the theoretical results. (Based on G. Zhao & S. Ruan, J. Math Pures Appl. 2023).

10:30-12:30pm, August 11
Refreshment provided before the lecture
Kinsmen Building: Room 277
York University, Keele campus

Organizer: Jianhong Wu, Judy Kong, Woldegebriel Assefa Woldegerima