PHY670A: EVOLUTIONARY GAME DYNAMICS 

Academic Year: 2023-2024; Semester I

I/C: Sagar Chakraborty, Department of Physics, IITK

Lectures: 1400–1500 hrs on Mondays, Tuesdays and Thursdays

(For any extra discussion-time or any queries, feel free to email at sagarc@iitk.ac.in)

Prerequisite: No serious prerequisite required but a taker of the course must not have a dislike for abstract mathematics. However, the preceding statement assumes that takers are either PG students or fourth-year UG students: UG students in their 3rd or 5th semesters may find the course overwhelming.

Objective: This is a curiosity-driven course where emphasis will be on developing mathematical and physical understanding of the concepts and formalisms pertaining to evolutionary game theory while going through the general introduction to the highly interdisciplinary topics of game theory, nonlinear dynamics, and stochastic process. Formal rigorous mathematical proofs will be avoided wherever they are avoidable in understanding the corresponding concepts physically or intuitively.

Details of Course-Content: **(1) Basics of evolution:** Examples of evolution in biology, ecology, society, and language; Darwin's theory; Mendel's Laws, Hardy–Weinberg principle; Wright's equation for adaptive landscape; Fisher's fundamental theorem; Price equation; Hamilton's inclusive fitness theory. **(2) Basics of game theoretic concepts:** Normal and extensive forms; dominant strategy equilibrium, Nash equilibrium, and evolutionary stable strategy; repeated games and evolution of cooperation. **(3) Games in infinite population (deterministic models):** Quasispecies equation; replicator-mutator equation; evolutionary stable state and its relation to the fixed points; evolutionary stable set; Folk theorem of evolutionary game theory; Bishop–Cannings theorem; connection between replicator-mutator equation and expanded Price equation; doubly symmetric matrix game and Fisher's fundamental theorem; examples like generalized rock-paper-scissors game, language evolution, etc.; mention of other game dynamics (imitation dynamics, monotone selection dynamics, best-response dynamics, adjustment dynamics, logit dynamics, adaptive dynamics, etc.). **(4) Games in finite population (stochastic models):** Fixation probability of alleles in Wright–Fisher model and Moran model, Kimura's neutral theory of evolution, Diffusion approximation (Kolmogorov forward and backward equations), games in finite population, one-third law and its relation with risk dominance, evolutionary stability, evolutionary graph theory, spatial games, deriving replicator equation from modified Moran model.

Selected Reference Books: **M. A. Nowak,** *Evolutionary Dynamics*, The Belknap Press of Harvard University Press (2006); **S. H. Rice,** *Evolutionary Theory,* Oxford University Press (2004); **J. Hofbauer and K. Sigmund,** *Evolutionary Games and Population Dynamics,* Cambridge University Press (1998); **J. Maynard Smith,** *Evolution and the Theory of Games,* Cambridge University Press (1982); **R. McElreath and R. Boyd**, *Mathematical Models of Social Evolution: A Guide for the Perplexed,* The University of Chicago Press (2007).

Course Policy:

1) Total marks (and corresponding grades) at the end of the course will be given out of 100 marks.
2) The mid-semester exam and the end-semester exam will carry a total of 40-Q1 and 60-Q2 marks respectively.
3) Depending on the response and performance of the class, there may be some pre-announced quizzes totalling Q1 marks before mid-sem exam and Q2 marks after mid-sem exam.
4) 100% attendance is expected. If a student is absent in more than 4 classes without availing institute sanctioned leaves, then 10 marks will be deducted. On missing more than 7 classes, the student's name may be forwarded to SUGC/SPGC/DOAA for deregistration from the course.
5) Absence in the end-semester exam will fetch the absentee I grade.
6) Only and only institute sanctioned leaves (medical or otherwise) will be considered as the excuses for absences during the lectures and the exams. Any request for make-up exams must come through SUGC/SPGC/DOAA.