ICRAMCS 2026

THE EIGHTH EDITION OF THE INTERNATIONAL CONFERENCE ON RESEARCH IN APPLIED MATHEMATICS AND COMPUTER SCIENCE
April 23-24-25, 2026 | Marrakech, Morocco

The Global Dynamics of the Fractional SEIQR Epidemic

Communication Info

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Keywords:

- (1) Fractional differential equations
- (2) SEIQR model
- (3) Reaction-diffusion

Abstract

This paper investigates the global dynamics of a fractional-order epidemic model with five compartments: susceptible, exposed, infectious, quarantined, and recovered individuals. The temporal evolution incorporates memory effects through a fractional derivative [1, 2, 3], while spatial movement is modeled by diffusion with homogeneous Neumann boundary conditions. We establish the well-posedness of the system by proving existence, uniqueness, positivity, and boundedness of solutions. A threshold parameter, the basic reproduction number $\mathbf{R}_0$, is derived and shown to completely determine the asymptotic behavior: when $\mathbf{R}_0 \leq 1$ the disease-free equilibrium is globally asymptotically stable, whereas for $\mathbf{R}_0 > 1$, a unique endemic equilibrium emerges and attracts all positive solutions. The analysis further reveals that fractional memory suppresses spatial pattern formation, leading to more homogeneous disease distribution [4, 5]. Numerical simulations using an L1-finite difference scheme validate the theoretical findings and demonstrate that decreasing the fractional order attenuates epidemic peaks. The study concludes with perspectives on extending the framework to abstract Hilbert spaces for a more general functional analytic treatment.

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