Contribution ID: **73** Type: **Poster**

Random Walks on Networks: Effective Distance, Entropy, and Fractional Dynamics

Tuesday, 14 April 2026 17:32 (7 minutes)

We develop a path-integral formulation of first-passage random walks on networks and extend it to fractional transport dynamics. In this framework, the random-walk effective distance is defined from the ensemble of all first-passage trajectories connecting a source to a target, weighted by both their probabilities and their lengths. This construction naturally introduces a trajectory partition function, an effective action, and a free-energy-like interpretation of transport on networks. We further define the Shannon entropy of the first-passage trajectory ensemble and node-level indicators based on total shortest-path and total random-walk effective distances.

The formalism is first analyzed in simple benchmark topologies, where it captures symmetry, boundary effects, hub dominance, and hierarchy. It is then generalized to the fractional case by replacing local random-walk dynamics with nonlocal transport induced by the fractional network operator. The results show that fractional dynamics reshapes effective distances, trajectory diversity, and node accessibility by enhancing long-range exploration across the network. Altogether, the framework provides a unified description of local and nonlocal spreading on networks and offers a basis for future applications to complex systems.

Primary author: CASTRO RODRIGUEZ, Juan Pablo (Universidad Nacional de Colombia)

Presenter: CASTRO RODRIGUEZ, Juan Pablo (Universidad Nacional de Colombia)

Session Classification: Poster session

Track Classification: Statistical Physics