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Time and space generalized diffusion on networks

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SUMMARY

Normal and anomalous diffusion are ubiquitous in many complex systems. Here, we define a time and space generalized diffusion equation (GDE), which uses fractional-time derivatives and transformed d-path Laplacian operators on graphs/networks. We find analytically the solution of this equation and prove that it covers the regimes of subdiffusion, normal diffusion, and superdiffusion as a function of the two parameters of the model. We extend the GDE to consider a system with temporal alternancy of normal and anomalous diffusion which can be observed for instance in the diffusion of proteins along a DNA chain. We perform computational experiments on a one-dimensional system emulating a linear DNA chain, where we shown that a subdiffusive-superdiffusive alternant regime allows the diffusive particle to explore more slowly small regions of the chain with a faster global exploration, than a subdiffusive-subdiffusive regime. Therefore, an alternancy of sliding (subdiffusive) with hopping and intersegmental transfer (superdiffusive) mechanisms show important advances for protein-DNA interactions.

Keywords: graph theory, fractional calculus, anomalous diffusion, DNA repair

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References

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