Abstract Submitted
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Expressing fractional derivatives as integer derivative series: physical and numerical applications[1] ANASTASIA GLADKINA, GAVRIIL SHCHEDRIN, Colorado School of Mines, USAMA AL KHAWAJA, United Arab Emirates University, LINCOLN D. CARR, Colorado School of Mines — Fractional derivatives, by extending the local definition of integer order derivatives to derivatives of non-integer order, are successful at describing systems with nonlocality, fat-tailed distributions, and multiscale hierarchy. In this work we use the displacement operator to derive an infinite series of integer order derivatives for the Grünwald-Letnikov fractional derivative. By truncating the infinite series and retaining only the first few terms, we find that functions normally characterized by Taylor series with a finite radius of convergence have an infinite radius of convergence in the integer derivative expansion, as is the case for a physically relevant hyperbolic secant function that represents a bright soliton. We show utility of the truncated integer derivative expansion by solving a linear fractional differential equation with constant coefficients by replacing the fractional derivative with integer derivatives up to the second order. This generates only a 1 percent error in the numerical solution. Such a decomposition is useful for the characterization of classical multi-scale materials, such as materials with memory or porous media, and can be further generalized to include quantum materials that are described by the fractional Schrödinger equation.

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