Numerical methods for non-standard fractional operators in the simulation of dielectric materials

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In materials exhibiting anomalous dielectric properties, the frequency domain constitutive law describing the polarization process is usually based on some nonlinear empirical models with one or more fractional powers.

When used in time domain, to simulate propagation of electric and magnetic fields in the Maxwell's systems, models of this kind often involve non-standard differential or pseudo-differential operators of fractional order [1] whose numerical approximation requires new and specifically devised methods.

In this talk we consider two models proposed in the recent literature to describe dielectric properties of a large extent of materials with anomalous dielectric properties: the Havriliak-Negami model and the Excess-Wing model. After discussing the mean features of the models, we analyze the operators involved for the description in the time domain (in particular the Prabhakar derivative [2] and special multiterm fractional differential equations) and we propose some approaches for their discretization in the numerical simulation of Maxwell's systems.

[1] R. Garrappa, F. Mainardi, G. Maione, Models of dielectric relaxation based on completely monotone functions. Fractional Calculus Applied Analysis, 2016, 19(5), 1105-1160

[2] R. Garra, R. Garrappa, The Prabhakar or three parameter Mittag--Leffler function: theory and application. Communications in Nonlinear Sciences and Numerical Simulation, 2018, 56, 314-329,