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Fractional calculus with an integral operator containing a generalized Mittag–Leffler function in the kernel

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ABSTRACT

In this paper, we introduce and investigate a fractional calculus with an integral operator which contains the following family of generalized Mittag–Leffler functions:

$$E^{\gamma,\delta}_{\alpha,\beta,\rho}(z) = \sum_{n=0}^{\infty} \frac{(\gamma)_{\rho n}}{\Gamma(\alpha n+\beta)\,(\delta)_n}\,\frac{z^n}{n!} \qquad (z,\beta,\gamma,\delta\in\mathbb{C};\ \Re(\alpha)>\max\{0,\Re(\rho)-1\};\ \Re(\rho)>0)$$

in its kernel, $(\gamma)_n$ being the familiar Pochhammer symbol. A number of corollaries and consequences of the main results presented here are also considered.

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1. Introduction, definitions and preliminaries

As mentioned in the survey article by Gorenflo and Mainardi [4], even the *classical* Mittag–Leffler functions have remained, for a long time, almost totally ignored in the common handbooks on special functions and tables of integral transforms, although a reasonably adequate description of many of their interesting and potentially useful properties appeared already in the *third* volume of the celebrated Bateman Manuscript Project (see Erdélyi et al. [2, Chapter 18]) in a chapter devoted to *Miscellaneous Functions*). The Mittag–Leffler functions $E_\alpha(z)$ and $E_{\alpha,\beta}(z)$ are defined by the following series:

$$E_\alpha(z) = \sum_{n=0}^{\infty} \frac{z^n}{\Gamma(\alpha n+1)} \qquad (z\in\mathbb{C};\ \Re(\alpha)>0) \tag{1.1}$$

and

$$E_{\alpha,\beta}(z) = \sum_{n=0}^{\infty} \frac{z^n}{\Gamma(\alpha n+\beta)} \qquad (z,\beta\in\mathbb{C};\ \Re(\alpha)>0), \tag{1.2}$$

respectively. These functions are natural extensions of the exponential, hyperbolic and trigonometric functions, since

$$E_1(z) = e^z, \quad E_2(z^2) = \cosh z \quad \text{and} \quad E_2(-z^2) = \cos z.$$

For a detailed account of the various properties, generalizations and applications of the Mittag–Leffler functions, the reader may refer to the recent works by (for example) Džrbašjan [1], Kilbas and Saigo [11], Gorenflo and Mainardi [4], Gorenflo et al.

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Fractional Calculus With An Integral Operator Containing A

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