Basics of fractional calculus and fractional order differential equations



2.1 Short history of fractional calculus and fractional order differential equations

Operators of fractional integro-differentiation play an important role in many modern fields of mathematics. For special function theory its importance is reflected in the title of the well-known paper [253] "All special functions are fractional integrals of elementary functions!" (But there is a remark of Professor A. A. Kilbas – all but Fox functions.)

In this section we list essential one- and multi-dimensional fractional operators and include some historical and priority information.

2.1.1 One-dimensional fractional derivatives and integrals

Euler's introduction in 1729 of the gamma function (1.1) allowed to expand the concept of factorial to the case of a fractional value of the argument. This, in turn, allowed Euler to note that the concept of the n-th order derivative of the power function x^p acquired meaning for a nonintegral n. Namely, let n, $p \in \mathbb{N}$ and $p \geq n$. It is well known that

$$(x^p)' = px^{p-1},$$
 $(x^p)'' = p(p-1)x^{p-2}, ...,$ $(x^p)^{(n)} = p(p-1)...(p-n+1)x^{p-n}$

Off

$$(x^p)^{(n)} = \frac{p!}{(p-n)!} x^{p-n}. \tag{2.1}$$

Expression (2.1) can also be meaningful for noninteger n and p. Namely, by virtue of the well-known equality for the gamma function

$$\Gamma(p+1) = p(p-1)...(p-n+1)\Gamma(p-n+1),$$

Varsha Daftardar-Gejji

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