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Evolutionary Equations with Material Laws Containing Fractional Integrals

Abstract

A well-posedness strategy for a time-shift invariant class of evolutionary operator equations as discussed in [1, 2] is applied to material laws involving fractional time-integration. This leads to evolutionary problems with fractional time-derivatives. Fractional time-differentiation is established in the framework of an function calculus for the time derivative ∂_0 as a normal operator. A class of such material laws of the form

$$\sum_{\alpha\in\Pi} \partial_0^{-\alpha} M_\alpha$$

with bounded, linear coefficient operator $M_\alpha : H \to H$, $\alpha \in \Pi$, H Hilbert space, where Π is a finite subset of $[0, 1]$, is characterized, for which well-posedness of the corresponding evolutionary problem

$$\left(\sum_{\alpha\in\Pi} \partial_0^{1-\alpha} M_\alpha + A\right) U = f,$$

where for example A is skew-selfadjoint in H, can be shown. The approach is exemplified by an application to a fractional Kelvin-Voigt type model in solid mechanics.

Bibliography

[1] Picard, R. and McGhee, D. F., *Partial Differential Equations: A Unified Hilbert Space Approach*, Volume 55 of *De Gruyter Expositions in Mathematics*. De Gruyter. Berlin, New York. 518 p., (2011).

[2] Picard, R., *A Class of Evolutionary Problems with an Application to Acoustic Waves with Impedance Type Boundary Conditions*, volume 221 of *Operator Theory, Advances and Applications*, pages 533–548. Birkhäuser Science, Springer, Berlin, (2012).