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Nonlocal Problem with Integral Condition For Homogeneous PDE

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In the strip $\Omega = \{(t,x) \in \mathbb{R}^2 : t \in (0,T), x \in \mathbb{R}\}$, we consider the nonlocal problem

$$\left[\frac{\partial}{\partial t} - a\left(\frac{\partial}{\partial x}\right)\right] U(t,x) = 0, \quad t \in [0,T], x \in \mathbb{R}, \tag{1}$$

$$p\left(\frac{\partial}{\partial x}\right) U(t,x)\Big|_{t=0} + q\left(\frac{\partial}{\partial x}\right) U(t,x)\Big|_{t=T} + \int_0^T U(t,x)dt = \varphi(x), \tag{2}$$

where $T > 0$, $a(\frac{\partial}{\partial x})$ is a differential expression with entire symbol $a(\lambda) \neq const$, $p\left(\frac{\partial}{\partial x}\right), q\left(\frac{\partial}{\partial x}\right)$ are differential polynomials.

By means of the differential-symbol method [1], we construct a solution of problem (1), (2) in the form

$$U(t,x) = \varphi\left(\frac{\partial}{\partial \lambda}\right)\Big\{\Phi(t,x,\lambda)\Big\}\Big|_{\lambda=0},$$

where $\Phi(t,x,\lambda)$ is a certain function constructed by functions $a(\lambda)$, $p(\lambda)$, $q(\lambda)$.

[1] P.I. Kalenyuk, Z.M. Nytrebych, *Generalized scheme of separation of variables. Differential-symbol method*, Publishing House of Lviv Polytechnic National University, Lviv, 2002.