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Newton's method for the McKendrick equation

We consider the initial value problem for the McKendrick equation with renewal

$$\begin{aligned} \frac{d\mathbf{u}}{dt} + \mathcal{A}(t)\mathbf{u} = \mathbf{u}\,\Lambda(t,\mathbf{u}), \quad t \in [0,T], \\ \mathbf{u}(0) = u_0 \end{aligned} \tag{1}$$

where

$$\begin{aligned} \mathcal{A}(t) &= c(t,x)\,\frac{\partial}{\partial x}, \\ \mathcal{D}(\mathcal{A}(t)) &= \{u(t,\cdot) \in C^1 \cap L^1 \cap L^\infty \;:\; u(t,0) = \mathcal{K}\mathbf{u}\}, \\ \mathcal{K}\mathbf{u} &= \int_0^\infty k(y)\,u(t,y)\,dy. \end{aligned}$$

We formulate the Newton scheme for (1) and prove its second order convergence.