Localization of the spectrum of a quadric pencil with a strong damping operator

N. Artamonov

In Hilbert space H we consider a quadric pencil

$$L(\lambda) = \lambda^2 I + \lambda D + A$$

with self-adjoint positive definite operator A. By H_s denote a collection of Hilbert spaces generated by operator $A^{1/2}$, $\|\cdot\|_s$ is a norm on H_s. We will assume that D is a bounded operator acting from H_1 to H_{-1} and

$$\inf_{x \in H_1, x \neq 0} \frac{\mathrm{Re}(Dx, x)_{-1,1}}{\|x\|_1^2} = \delta > 0.$$

(here $(\cdot,\cdot)_{-1,1}$ is a duality pairing on $H_{-1} \times H_1$). We obtain a localization of the spectrum of $L(\lambda)$:

$$\sigma(L) \subset \{\lambda \in \mathbb{C} \mid \mathrm{Re}\lambda \leq -\omega, |\mathrm{Im}\lambda| \leq \kappa|\mathrm{Re}\lambda|\}$$

for some positive $\omega, \kappa > 0$.

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