Contribution ID: **42** Type: **not specified**

Antagonistic cost functionals in shape optimization

Thursday, 15 June 2023 11:30 (1 hour)

In several shape optimization problems one has to deal with cost functionals of the form $\mathcal{F}(\Omega) = F(\Omega) + kG(\Omega)$, where F and G are two shape functionals with a different monotonicity behavior and Ω varies in the class of domains with prescribed measure. In particular, the cost functional $\mathcal{F}(\Omega)$ is not monotone with respect to Ω and the existence of an optimal domain in general may fail. An interesting situation occurs when the functional $F(\Omega)$ is minimized by a ball, while the functional $G(\Omega)$ is maximized by a ball; several examples of this kind are present in the literature. We consider the particular case $\mathcal{F}(\Omega) = \lambda(\Omega)T^q(\Omega)$ where $\lambda(\Omega)$ is the first eigenvalue of the Dirichlet Laplacian, and $T(\Omega)$ is the so-called torsional rigidity; the interesting cases are q small for the minimum problem and q large for the maximum problem.

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