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A Regularity Result in a Shape Optimization Problem with Perimeter

We consider optimal shapes of the functional

$$\mathcal{E}_\lambda(\Omega) = J(\Omega) + P(\Omega) + \lambda||\Omega| - m|$$

among all the measurable subsets Ω of a given open bounded domain $D \subset \mathbf{R}^d$ where $J(\Omega)$ is some Dirichlet energy associated with Ω, $P(\Omega)$ and $|\Omega|$ being respectively the perimeter and the Lebesgue measure of Ω. We prove here that for some optimal shape, the state function associated with the Dirichlet energy is Lipschitz-continuous. Then we deduce the same regularity properties for the boundary of the optimal shape as in the pure isoperimetric problem (case $J \equiv 0$). We also consider the minimization of $\mathcal{E}_0$ with Lebesgue measure constraint $|\Omega| = 0$.