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Heat trace and Riesz means with a large Robin parameter

We consider the Laplacian with Robin boundary conditions on a smooth Riemannian manifold with boundary and investigate the behavior of various spectral quantities as the Robin parameter approaches infinity. Although the spectrum, heat trace, and Riesz means converge pointwise to their Dirichlet analogues, the $asymptotics$ of these quantities as the spectral parameter approaches infinity, or as time approaches zero, do not. We investigate this phenomenon and explain the divergent behavior. Our main result is a two-term asymptotic expansion for the Robin heat trace that depends jointly on the time variable and the Robin parameter, with a remainder that satisfies a uniform bound independent of the Robin parameter. We apply this result to obtain a similar two-term asymptotic expansion for Riesz means.