Inequalities between Neumann and Dirichlet Laplacian eigenvalues on planar domains

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We generalize a classical inequality between the eigenvalues of the Laplacians with Neumann and Dirichlet boundary conditions on bounded, planar domains: in 1955, Payne proved that below the k-th eigenvalue of the Dirichlet Laplacian there exist at least k+2 eigenvalues of the Neumann Laplacian, provided the domain is convex. It has, however, been conjectured that this should hold for any domain. Here we show that the statement indeed remains true for all simply connected planar Lipschitz domains. The proof relies on a novel variational principle.