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Narrow escape problems: asymptotic optimization of small trap locations for the unit sphere

We first consider the motion of a Brownian particle in a sphere with an almost entirely reflecting boundary, containing small absorbing windows. In the limit of asymptotically small total window area, we compute three leading terms of the mean first passage time (MFPT), the average time required for a randomly placed Brownian particle to escape from the domain. The third term of the asymptotic expansion depends on relative window locations. We study this dependence and numerically compute configurations of N identical windows which minimize the MFPT, for $2 \leq N \leq 20$.

A related problem with totally reflecting boundary and *interior* spherical traps of asymptotically small radii is also considered. Three terms of asymptotic expansion of the MFPT are computed, and optimal N-trap volume configurations are found for $2 \leq N \leq 20$.

It is also shown that the problem of asymptotic minimization of MFPT, for both of the above set-ups, is equivalent to the problem of maximization of the principal eigenvalue of the Laplacian in each respective domain.