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Maximum energy transfer in nanoscale thermal radiation[1]

SOUMYADIPTA BASU, ZHUOMIN ZHANG, Georgia Institute of Technology —

Radiation heat transfer between closely spaced objects has received much attention lately because of the emerging applications of near-field thermophotovoltaics, thermal radiation scanning tunneling microscopy, and nanothermal manufacturing. The energy transfer in nanoscale radiation can exceed that of blackbody radiation by several orders of magnitude due to photon tunneling and the excitation of surface polaritons. An outstanding question remains as whether there exists an upper limit of near-field radiation for arbitrarily selected material properties. We examine the maximum radiative energy flux between two parallel plates separated by a vacuum gap from 0.1 and 100 nm distance. An upper bound is imposed to the parallel wavevector component in the analysis based on fluctuational electrodynamics. By assuming a frequency-independent dielectric function, we find that the maximum heat flux depends on the chosen complex permittivity and the distance. The determination of the achievable heat flux at nanometer distances will benefit future research and applications of near-field radiation for energy harvesting.

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Zhuomin Zhang
Georgia Institute of Technology

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