Microscopic theory of the Casimir force at thermal equilibrium: Large-separation asymptotics

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We present an entirely microscopic calculation of the Casimir force f (d) between two metallic plates in the limit of large separation d. The models of metals consist of mobile quantum charges in thermal equilibrium with the photon field at positive temperature T. Fluctuations of all degrees of freedom, matter and field, are treated according to the principles of quantum electrodynamics and statistical physics without recourse to approximations or intermediate assumptions. Our main result is the correctness of the asymptotic universal formula f (d) ?- ? (3) kB T 8? d3, d?. This supports the fact that, in the framework of the Lifshitz theory of electromagnetic fluctuations, transverse electric modes do not contribute in this regime. Moreover, the microscopic origin of universality is seen to rely on perfect screening sum rules that hold in great generality for conducting media.