Temperature gradients induced by strongly-coupled radiative and conductive heat transfer at the nanoscale

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The radiative heat transfer between two bodies held at two different temperatures is limited by Stefan-Boltzmann law in the far field, i.e. for distances much larger than the thermal wavelength. For smaller distances, this energy transfer can increase by orders of magnitude as a result of tunnelling of evanescent waves. In spite of this enhancement, radiative heat transfer remains less efficient than conduction in common scenarios. The recent realization of materials having ultralow thermal conductivity leaves open the possibility that radiative heat transfer can reach or exceed conduction under ambient conditions.

We present here a coupled treatment of radiation and conduction [1], based on the recent introduction of a fluctuating-volume-current method to compute radiative heat transfer in arbitrary geometries [2]. Our treatment is able to describe the interplay between the two phenomena and to fully account for the temperature profile within each body. We first apply this method to study two parallel thin films. In this case, for distances in the nanometer range, we predict temperature gradients within each slab up to 100 K. We show that solving the fully-coupled problem is necessary not only to predict the right temperature profile but also to correctly describe the radiative heat transfer. Finally, we apply our formalism to an arrangement of nanorods, which show even larger temperature gradients because of the participation of bulk resonances of the field.

1. W. Jin, R. Messina, and A. W. Rodriguez, in preparation (2016).
2. A. G. Polimeridis, M. Reid, W. Jin, S. G. Johnson, J. K. White, and A. W. Rodriguez, Phys. Rev. B **92**, 134202 (2015).