Nanoscale heat transfer between hyperbolic media

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In our physics courses we usually learn/teach that the energy transfered between two macroscopic semi-infinite materials by radiation is always smaller than that between two black bodies. Hence, Stefan-Boltzmanns law which describes the energy transfer between two black bodies sets an upper limit to the amount of heat which can be transported. For distances smaller than the thermal wavelength which is given by Wiens law such a statement is not true anymore. In fact, the heat flux at such a length scale can be by orders of magnitude larger than between two black bodies [1]. This increasement can be attributed to the contribution of evanescent modes [2, 3, 4] (frustrated total internal reflection modes and surface modes) which are not taken into account in Stefan-Botzmanns law. In particular, for dielectric materials which support surface phonon polaritons in the infrared the heat flux will become proportional to the inverse of the distance squared and quasi-monochromatic [5, 6]. Due to these facts, the nanoscale heat transfer seems to be promising for several applications such as near-field thermophotovoltaics [7] and thermal near-field imaging [8, 9, 10]. I will first give a short introduction into the topic explaining the different heat transfer mechanisms at the nanoscale. In addition, I will introduce a Landauerlike [11, 12] expression for the heat flux, and discuss some very recent experiments [13, 14, 15, 16]. Then I will give an overview over some of the theoretical trends in the past and discuss the nanoscale heat transfer between anisotropic media [17] in detail. In particular, metamaterials in the long-wavelength limit can be regarded as such anisotropic materials. Here, I will focus on the nanoscale heat transfer between hyperbolic materials [18, 19, 20] and discuss the question: Is there a black body for near-field thermal radiation? And, how could it look like?

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