REDUCING THERMAL RADIATION HEAT TRANSFER WITH INTERFERENCES

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EXTENDED ABSTRACT. It is well known that the tunneling of evanescent electromagnetic waves thermally excited induces an increase of radiative heat transfer, which can exceed the blackbody limit valid for the far-field. This tunneling happens when the distance between the hot and the cold bodies exchanging heat through thermal radiation becomes smaller than the dominant wavelength. The enhancement of the radiative heat exchange could be advantageous for the development of nanoscale-gap thermophotovoltaic (TPV) systems [1] and near-field thermal microscopy [2, 3]. When the distance becomes comparable to the dominant wavelength, effects of coherence of thermal radiation [4] also appear because reflected propagative waves can interfere. In a previous research work [5], interference of thermally-excited waves was experimentally investigated in micron-size cavities. In this case, the coexistence of both constructive and destructive interferences allowed for the selection of given wavelengths in the cavities. Oscillations of the thermal-radiation signal linked to coherence were also observed in near-field infrared microscopy experiments [6]. It is important to realize that these two effects, namely the increase due to tunneling and the reduction due to destructive interference, can compete for certain distance ranges between the bodies.

The present work investigates the conditions that allow for the reduction of the net radiative heat exchange caused by the interferences while avoiding the evanescent contribution to hide this decrease. For the sake of simplicity, the case of two semi-infinite plane-parallel plates is studied. In previous theoretical papers [7-9], a reduction of the propagating component of radiative heat flux caused by interferences is observed, but the total heat exchange considering propagating and evanescent waves does not exhibit a significant decrease because the evanescent contribution overrides the drop caused by the interference. Here, we search for conditions that permit to maximize the drop while avoiding its disappearance because of the evanescent waves. For that purpose, radiative heat transfer fluxes are calculated as a function of the distance between the bodies for various dielectric and metallic materials using the well-known expression of radiative heat transfer between two semi-infinite parallel plates [10, 11]. This allows us highlighting optimal materials and distances. These results will contribute to help designing an experimental setup that would prove the concept of lowering net radiative heat flux between plates below the far-field value. As potential application, this work could be a basis for the development of new thermal insulation systems.

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