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二次元表面フォノンポラリトンの熱伝導制御

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研究成果の概要

WorkPackage 1-Proof of concept

- Substantial surface plasmon polariton heat conduction predicted in graphene on silicon

We have investigated the contribution of graphene plasmon to heat conduction and uncover the unexpected existence of three modes among which modes with very long propagation length carried inside silicon. The overall thermal conductivity of plasmons reach the one of the silicon film with thickness smaller than 20nm.

WorkPackage 2-Guiding and Tunneling

- Demonstration of the existence of a guided radiative emission, in addition to the planckian one

The Surface Phonon-Polaritons (SPhPs) contribution to the gap heat flux between two 2D waveguides made of silicon films coated with silica, is experimentally demonstrated. We could show that this contribution adds to the planckian one, yielding a total heat flux higher than the Planck flux. This result was predicted by our theory and by direct numerical calculations based on fluctuational electromagnetism. The article 2) finally introduces the new concept of 'low-dimensional' thermal radiation.

- SPhP heat conduction in a cylindrical cavity made of SiO_2 via guided modes

We have predicted the thermal radiation generated by the guided modes inside a cylindrical SiO_2 cavity and found the apparition of higher order modes when the radius increases. When the radius exceeds 1mm, the thermal radiation suddenly decreases due to the decoupling of surface waves inside the cavity.

【代表的な原著論文情報】

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2) S. Tachikawa, J. Ordonez-Miranda, L. Jalabert, Y. Wu, R. Anufriev, B. Kim, H. Fujita, S. Volz, M. Nomura, Enhanced Far-Field Thermal Radiation through a Polaritonic Waveguide, Physical Review Letters 132 (18), 186904, (2024). (2)

3) J. Ordonez-Miranda, M. Coral, M. Nomura, S. Volz, Resonant Thermal Transport Driven by Surface Phonon-Polaritons in a Cylindrical Cavity, International Journal of Thermophysics 44 (5), 73, (2023). (3)