Radiative heat transfer with cylindrical waveguides

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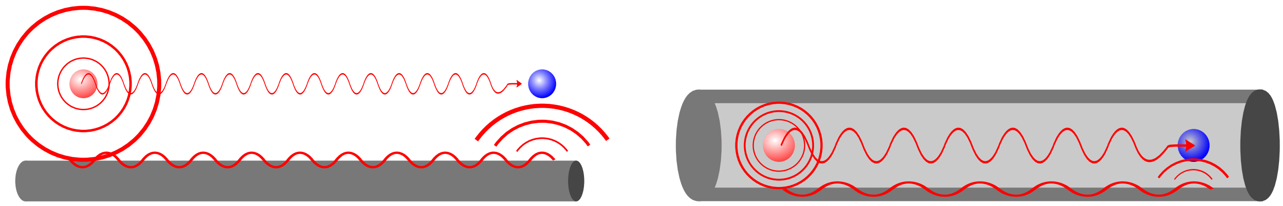
In everyday life, one typically uses cylindrical objects to transfer matter, energy, or information from one location to another: Pipes are used for transferring liquids, wires for electricity, and optical fibers for the Internet data. On the other hand, electromagnetic energy can travel without any objects or media, but the efficiency of transferring this energy is expected to be much better when employing cylindrical waveguides.

Using the fluctuational electrodynamics and the Green's functions of cylindrical objects, we address the problem of radiative heat transfer from a hot nanoparticle to a cold one in the presence of a cylindrical waveguide. We consider the particles to be outside a cylinder or inside a cylindrical cavity. In both cases, the heat transfer can be very long ranged, greatly outperforming the previously studied heat transfer with planar or spherical waveguides. We investigate different geometrical configurations and different materials of the cylinder, finding a variety of interesting effects.



An illustration of radiative heat transfer between two nanoparticles placed close to a cylinder or inside a cylindrical cavity parallel to the cylinder axis. A cylindrical waveguide can capture the near-field energy radiated by one particle and transfer it in the needed direction to another particle via surface waves. Such a directional energy propagation leads to a highly efficient heat transfer even for far-separated particles.

References

- S.-A. Biehs, R. Messina, P.S. Venkataram, A. W. Rodriguez, J. C. Cuevas, and P. Ben-Abdallah, *Near-field radiative heat transfer in many-body systems*, Rev. Mod. Phys. **93**, 025009 (2021).
- K. Asheichyk and M. Krüger, *Radiative heat transfer with a cylindrical waveguide decays logarithmically slow*, Phys. Rev. Lett. **129**, 170605 (2022).
- K. Asheichyk, P. Ben-Abdallah, M. Krüger, and R. Messina, *Long-range super-Planckian heat transfer between nanoemitters in a resonant cavity*, Phys. Rev. B **108**, 155401 (2023).
- J.-Y. Wang, Y. Zhang, C.-L. Zhou, Y. Shuai, and H.-L. Yi, *Enhanced radiative heat transfer via propagating surface modes in a dielectric nanowire*, Phys. Rev. B **109**, 075423 (2024).
- K. Asheichyk and M. Krüger, *Heat radiation and transfer for nanoparticles in the presence of a cylinder*, Phys Rev. B **109**, 125412 (2024).