Blackhole-Inspired Thermal Trapping with Graded Heat-Conduction Metadevices

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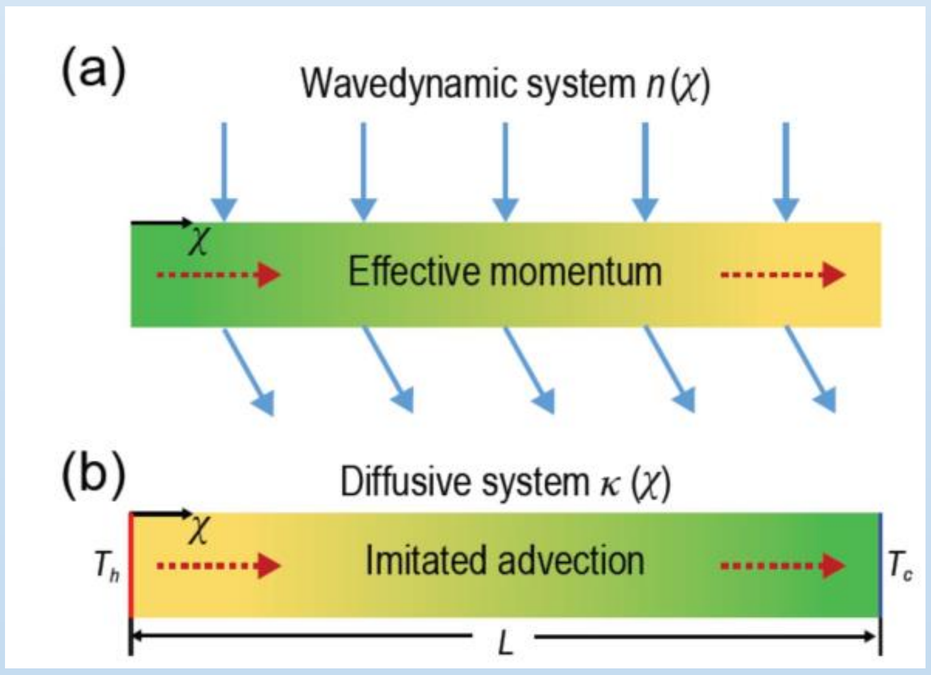
Abstract

Inspired by black holes, we construct graded heat-conduction metadevices to achieve thermal trapping, resorting to the imitated advection produced by graded thermal conductivities rather than the trivial solution of using insulation materials to confine thermal diffusion. Our experiments demonstrate the guiding hot spots to diffuse normally or rotationally towards the center.

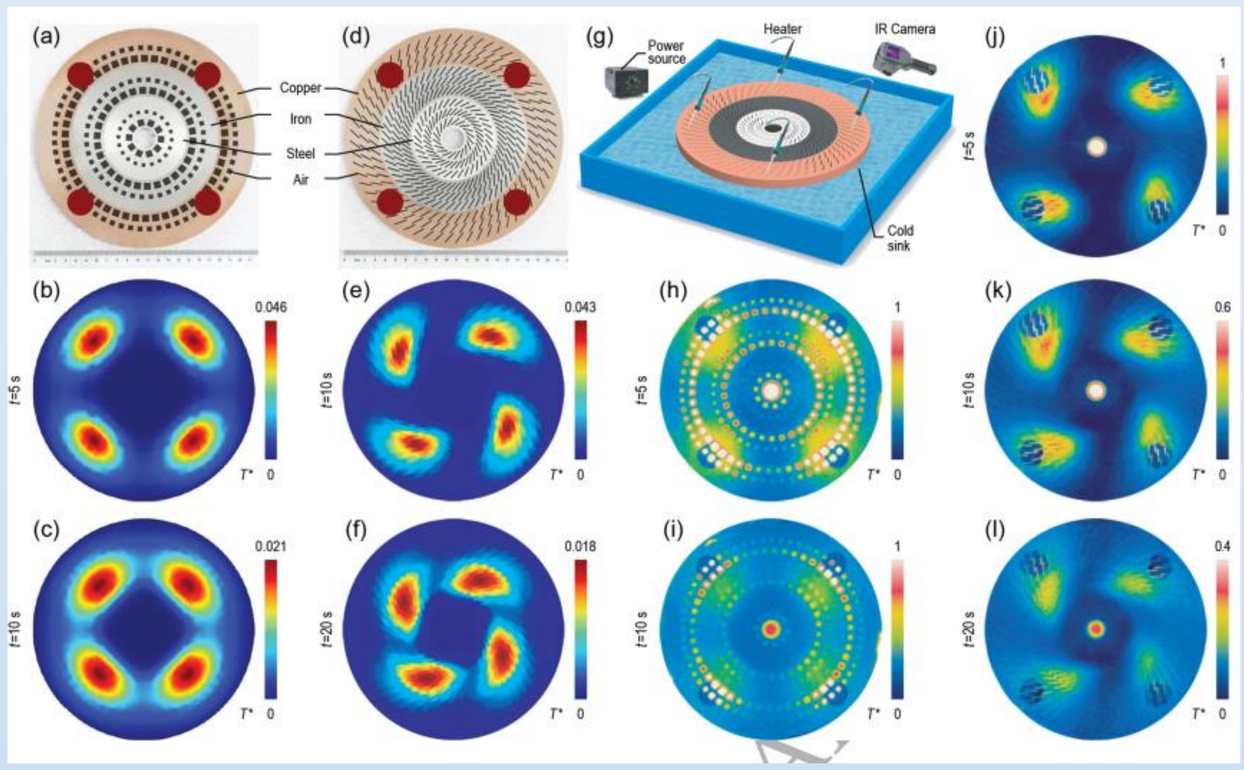
Theory

$$\rho c(x)\partial_t T + \partial_x(\kappa(x)\partial_x T) = 0$$
with $\kappa \sim \rho c \sim e^{\alpha x}$

Gradient parameters ->
Effective advection ->
Asymmetric temperature profiles

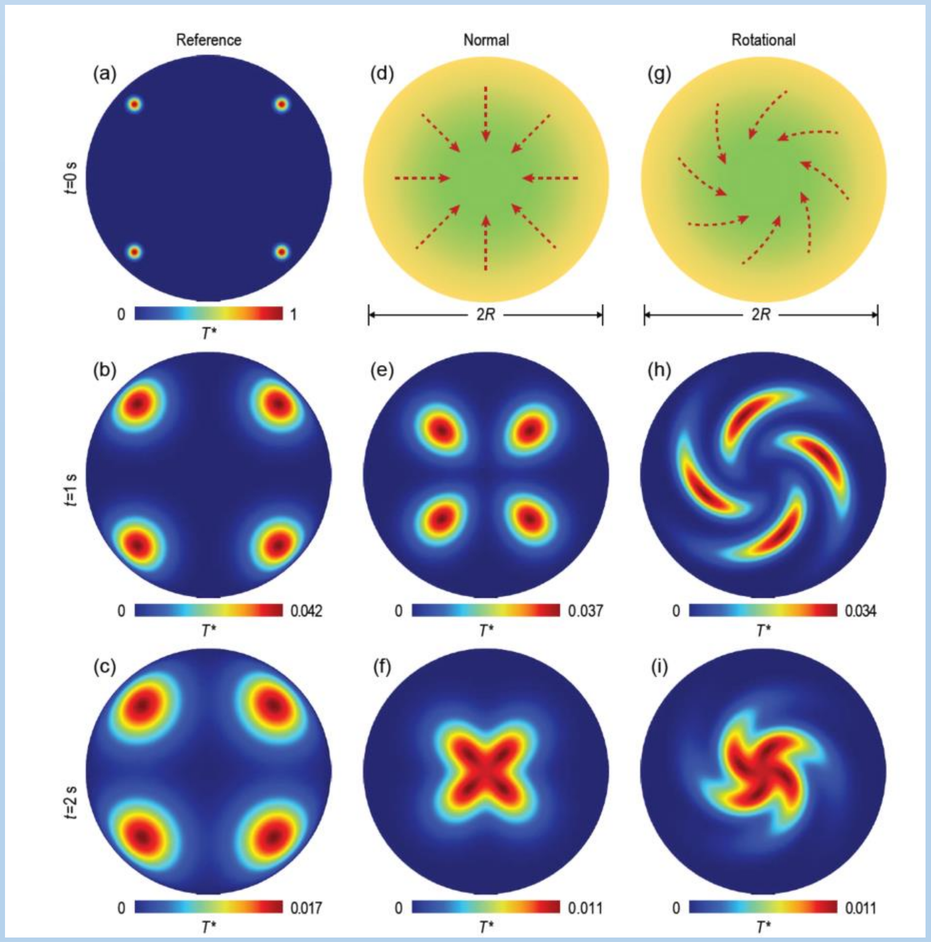


Thermal trapping (experiments)



The hot spots are trapped (b and c, simulations) with the graded metadivice. Under the rotational transformation, the hot spots are trapped and rotated (e and f, simulations) with graded and anisotropic metadivice. Experiments (g-i) validate the trapping effect with time.

Thermal trapping (simulations)



Conclusion

We reveal blackhole-inspired thermal trapping with graded heat-conduction metadevices. The underlying mechanism lies in the imitated advection induced by graded thermal conductivities as a counterpart to graded refractive indexes responsible for the effective momentum in photonics.

Reference

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