Light-field control of real and virtual charge carriers [1]

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Light-driven electronic excitation is a cornerstone for energy and information transfer. In the interaction of intense and ultrafast light fields with solids, electrons may be excited irreversibly, or transiently during illumination only. As the transient electron population cannot be observed after the light pulse is gone, it is referred to as virtual, whereas the population that remains excited is called real. Virtual charge carriers have recently been associated with high-harmonic generation and transient absorption, but photocurrent generation may stem from real as well as virtual charge carriers. However, a link between the generation of the carrier types and their importance for observables of technological relevance is missing. In Ref. 1 we show that real and virtual charge carriers can be excited and disentangled in the optical generation of currents in a gold–graphene–gold heterostructure using few-cycle laser pulses. Depending on the waveform used for photoexcitation, real carriers receive net momentum and propagate to the gold electrodes, whereas virtual carriers generate a polarization response read out at the gold–graphene interfaces. On the basis of these insights, we further demonstrate a proof of concept of a logic gate for future lightwave electronics. Our results offer a direct means to monitor and excite real and virtual charge carriers. Individual control over each type of carrier will markedly increase the integrated-circuit design space and bring petahertz signal processing closer to reality.

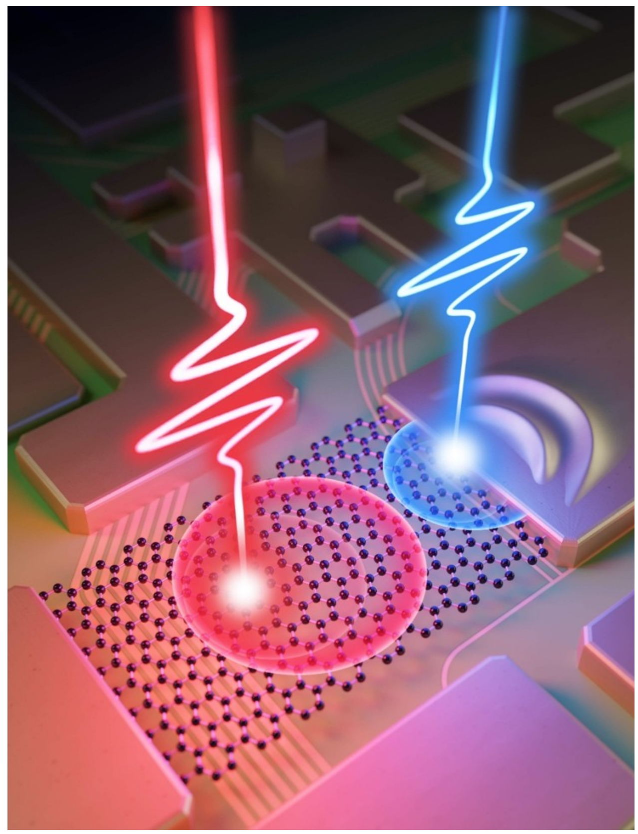

Figure 0: *Light-driven petahertz logic gate.*

Index Terms: quantum control, strong light-matter interactions, photocurrents, quantum transport.

[1] T. Boolakee, C. Heide, A. Garzón-Ramírez, H. B. Weber, I. Franco, P. Hommelhoff, Nature, 605, 251-255 (2022)