Double-bended saturation of optically induced bleaching in graphene

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Saturable absorption due to Pauli blocking is a fundamental optical phenomenon that can be described fully analytically for a two-level system. In solids, the related carrier dynamics is typically much more complex. Nevertheless, the fluence dependence of the induced bleaching is typically qualitatively similar to the behaviour of a two-level system. Saturable absorbers are important photonic devices for realizing short laser pulses.

We present a joint theory-experiment study, where the bleaching of graphene is studied in a wide range of fluences. In pump-probe experiments utilizing 30 fs near-infrared (λ = 800 nm) pulses the pump-induced transmission is measured. The study reveals an unusual double-bended saturation behaviour. For fluences in the mJ/cm^2 range the induced transmission saturates due to Pauli blocking. Interestingly, a qualitatively similar behaviour is found at fluences that are 1000 times smaller. In this range one would expect a linear fluence dependence of the induced transmission. Microscopic theory based on the density matrix formalism shows that the unexpected saturation at low fluences is related to intensity dependent many-particle scattering. The crucial point is the balance between in- and out-scattering of electrons from the optically excited k-space regions. The occupation of this region determines the observed transmission [1].

Figures

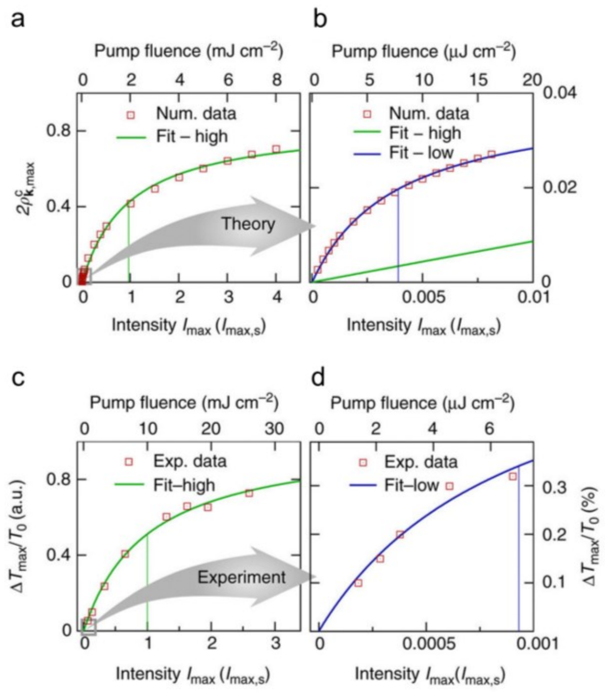

Figure 1: Calculated (a,b) and experimental (c,d) saturation behaviour at high (a,c) and low (b,d) fluences. Dots represent experimental and theoretical results, respectively, lines are fits using the equation for a two-level system. Figure adapted from Ref. [1].

Full understanding of the saturation behaviour in graphene is of relevance for graphene-based saturable absorbers. Graphene is an interesting material for this purpose as it can be applied in a very broad spectral range from THz to UV [2,3]. Also the high damage threshold, which is verified in our experiments, is an attractive feature.

References

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