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Photo-excited semiconductor superlattices as constrained excitable media: Motion of dipole domains and current self-oscillations

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— A model for charge transport in undoped, photo-excited semiconductor superlattices, which includes the dependence of the electron-hole recombination on the electric field and on the photo-excitation intensity through the field-dependent recombination coefficient, is proposed and analyzed. Under dc voltage bias and high photo-excitation intensities, there appear self-sustained oscillations of the current due to a repeated homogeneous nucleation of a number of charge dipole waves inside the superlattice. In contrast to the case of a constant recombination coefficient, nucleated dipole waves can split for a field-dependent recombination coefficient in two oppositely moving dipoles. The key for understanding these unusual properties is that these superlattices have a unique static electric-field domain. At the same time, their dynamical behavior is akin to the one of an extended excitable system: an appropriate finite disturbance of the unique stable fixed point may cause a large excursion in phase space before returning to the stable state and trigger pulses and wave trains. The voltage bias constraint causes new waves to be nucleated when old ones reach the contact.

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