Universidad Carlos III de Madrid

Seminario del Instituto Gregorio Millán

Photoexcited superlattices as constrained excitable media: Motion of dipole domains and current self-oscillations

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Resumen

Vertical electronic transport in undoped, photoexcited and voltage biased $Al_xGa_{1-x}As$/GaAs superlattices is investigated on the basis of a spatially-discrete sequential-resonant-tunneling model governed by differential-difference equations. The recombination, drift velocity and diffusion coefficients are calculated numerically as functions of the electric field according to the overlap of the electron wave functions and microscopic scattering process.

At constant current bias and depending on the laser intensity, the model equations resemble those of the FitzHugh-Nagumo (FHN) model of nerve conduction. Depending on parameter values, the dynamics may be excitable or oscillatory, and wave fronts, pulses and wave trains are among attractors. Asymptotic approximations of these different waves need to go one order beyond those develop for the spatially discrete FHN model in order to agree with the numerical simulations. There are other waves, pulses moving against the electron flow, which are qualitatively different from the FHN ones.

Under dc voltage bias our system may have excitable or oscillatory dynamics but such dynamics is constrained by the requirement that the area under the electric field should be a constant. For large enough voltage, there may appear self-sustained oscillations of the current due to charge dipole waves which are pulses of the electric field. Besides self-oscillations of Gunn-type due to dipole creation at the injector, there are novel oscillations due to repeated homogeneous nucleation of opposite-moving dipole pairs inside the sample. Some of these oscillations are weakly chaotic as they have a positive Lyapunov exponent.

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