OFFICE OF NAVAL RESEARCH

FINAL REPORT

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Electronic Transport in III-V Semiconductors and their Lattice Matched Heterojunctions

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ACCOMPLISHMENTS AT THE TIME OF COMPLETION OF THE CONTRACT

We have performed research in a broad range of nonlinear transport in semiconductor heterojunction layers. Our accomplishments include the

- Discovery of new effects of **structure in momentum and real space** on nonlinear transport effects (1,2,3,4). For example, the band structure leaves a particularly pronounced footprint on the momentum distribution when electrons propagate over band edge discontinuities. Fig. 1 shows such a momentum distribution reflecting the Γ, L and X valleys in GaAs at room temperature and an electric field of 100 kV/cm.

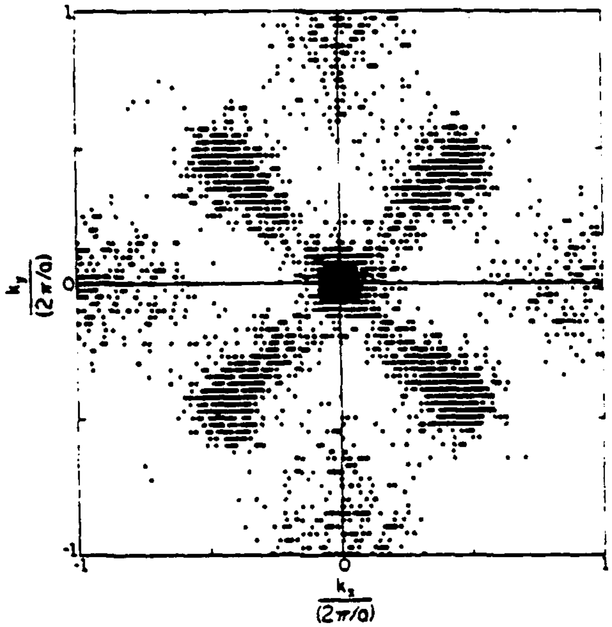

Fig. 1

- First classical theory of the influence of **confining fields** on the electron temperature (5).
- Assessment of the impact of **barrier height fluctuations in small devices** due to the discreteness of the dopants (6).
- Assessment of the effect of **reflecting contacts** on high field transport and **overshoot effects** (7,8).

- Experiments and theory of **real space transfer in presence of magnetic fields** (9). Fig. 2 shows real space transfer in NERFET's in the presence of magnetic fields. Notice that at small electric fields there is virtually no magnetoresistance while there is a pronounced one at high electric fields. This demonstrates the transition from a two-dimensional electron gas to three-dimensional propagation (real space transfer).

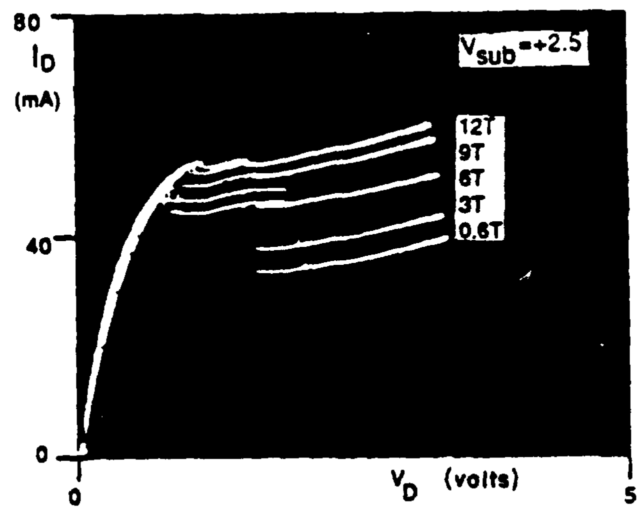

Fig. 2

- Study of **phonon scattering in heterolayers** at low temperatures (10).
- Complete numerical study of **interface transport including five subbands** and self-consistent envelope wavefunctions (11).
- Discovery of a **new switching mechanism in hot electron heterojunction diodes** (12,13,14).
- Computation of the **scaling properties of the high electron mobility transistor** using a two-dimensional model (15,16).
- Simulation of **hot electron transfer amplifiers** including coupled plasmon- phonon modes and Landau damping (17).

- Theory of **quantum transport by use of the Feynman-Vernon path integral formalism** (18). Fig. 3 shows the density matrix as a function of time and distance as numerically computed by using the Feynman-Vernon path integral technique. The computations are valid for arbitrary electron-phonon coupling strength. The inset is for vanishing electron-phonon interaction

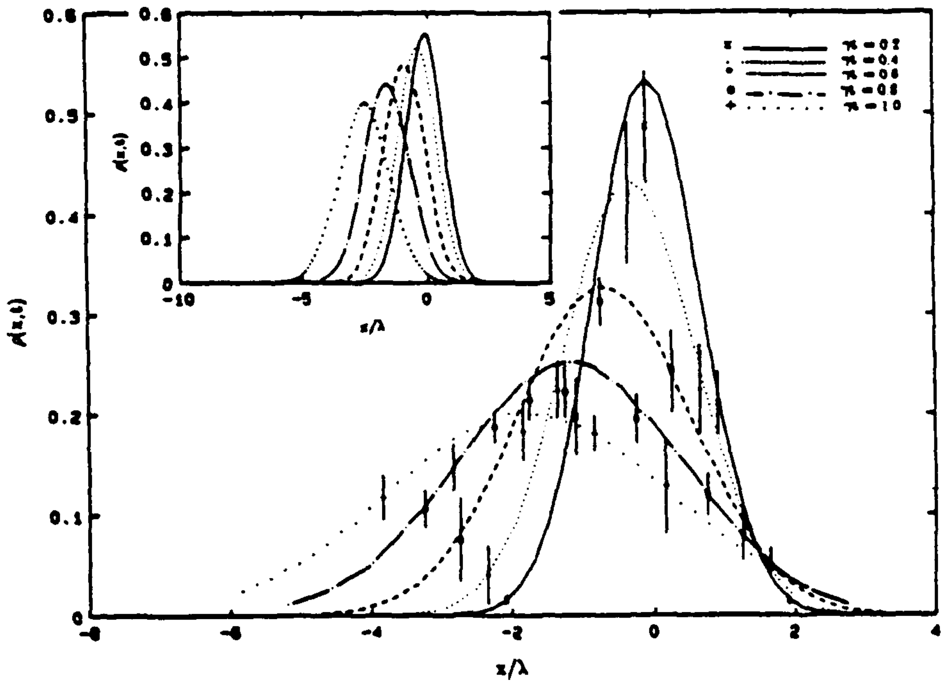

Fig. 3

- First inclusion of **collisional broadening into Monte Carlo transport** and assessment of the effects of band structure on this effect (19).
- First Monte Carlo simulation of **impact ionization in non-uniform electric fields** (theory of the "dead-space") (20,21).
- Monte Carlo theory of the **effects of field fluctuations** on the impact ionization rate (22).
- Demonstrated that impact ionization is most sensitive to the density of states at high energies in semiconductors and assessed **impact of use of different band-structure theories** (23).
- Reviewed and summarized various aspects of heterolayer transport in high electric fields (24,14,25,26).

INDEX OF PUBLICATIONS

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