# Modeling and 2d–Simulation of Quantum–Well Semiconductor Lasers including the Schrödinger–Poisson system

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Modeling semiconductor lasers has to face the electronic behaviour of the semiconductor, the optical field, and the interaction of both systems. That leads to the stationary Van–Roosbroeck system with selfconsistent optical modes on the device domain. The lasing region usually is a nanostructure, one or more quantum wells, quantum wires or qunatum dots, and quantum effects are an important feature of the semiconductor diode laser. This requires the solution of Schrödinger's equation in real space and its embedding into the classical transport equations. This project is concerned with mathematical and numerical methods for the solution of Schrödinger–Poisson systems with a selfconsistent effective Kohn–Sham potential, which model the electronic properties of a nanostructure. The inclusion of Schrödinger–Poisson type systems into the macroscopic semiconductor equations and their selfconsistent treatment in the Two dimensional Semi-Conductor Analysis package WIAS-TeSCA provides a tool for the developnent of nanoelectronic devices, which is available to the wide spread WIAS-TeSCA users community. In particular this branch of WIAS-TeSCA serves the development of quantum well diode lasers at the FBH. There simulation with WIAS-TeSCA allows a more accurate prediction of the band edges and carrier densities and thus, the intensity of the laser.

# Publications within the Project

## Publications in Journals and Books

- H.-Chr. Kaiser and J. Rehberg. On stationary Schrödinger–Poisson equations. *Zeitschrift für Angewandte Mathematik und Mechanik – ZAMM*, 75:467–468, 1995.
- H. Wenzel and G. Erbert. Simulation of single–mode high–power semiconductor lasers. *SPIE*, 2693, 1996. Physics and Simulation of optoelectronic devices IV.
- H.-Chr. Kaiser and J. Rehberg. On stationary Schrödinger–Poisson equations modelling an electron gas with reduced dimension. *Mathematical Methods in the Applied Sciences*, 20:1283–1312, 1997.
- H. Gajewski, H.-Chr. Kaiser, J. Rehberg, H. Stephan, and H. Wenzel. Modellierung und Simulation von Quantum–Well–Halbleiterlasern. In K.-H. Hoffmann, W. Jäger, T. Lohmann, and H. Schunk, editors, *Mathematik:Schlüsseltechnologie für die Zukunft*, pages 281–291. Springer, Berlin, 1997.

## Congress Communications

- H. Gajewski and H.-Chr. Kaiser. Modellierung und 2d–Simulation von Quantum–Well–Halbleiterlasern unter Einbindung des Schrödinger–Poisson–Systems. BMFT–Workshop “Numerische Behandlung von Differentialgleichungen” an der Christian–Albrechts–Universität zu Kiel, 15.–16. November 1994.
- H.-Chr. Kaiser. About a stationary Schrödinger–Poisson system in nanoelectronics. 11th GAMM–Seminar on Numerical Treatment of Coupled Systems, Kiel, January 20 – 22, 1995.
- H. Gajewski, H.-Chr. Kaiser, and H. Stephan. Modellierung und Simulation von Quantum–Well Halbleiterlasern. Kolloquium des Weierstraß–Institutes für Angewandte Analysis und Stochastik Berlin, 10. April 1995.
- H.-Chr. Kaiser and J. Rehberg. On the numerical treatment of the 2d stationary Schrödinger–Poisson equation in nanostructure semiconductor device modeling. The Third International Congress on Industrial and Applied Mathematics, ICIAM 95, Hamburg, Germany, July 3 — 7, 1995.

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- J. Rehberg and H.-Chr. Kaiser. About a stationary Schrödinger–Poisson system modeling quantum structures. The Fourth International Seminar on Simulation of Devices and Technologies, ISSDT'95, Berg–en–Dal, South Africa, 15 – 17 November 1995.
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- H.-Chr. Kaiser and J. Rehberg. The Schrödinger–Poisson system with Kohn–Sham potential — analysis and numerical treatment. Ninth III–V Semiconductor Device Simulation Workshop, Eindhoven University of Technology, may 9 – 10, 1996.
- H.-Chr. Kaiser and J. Rehberg. Simulation of nanoelectronic devices with ToSCA including the stationary Schrödinger–Poisson system with a Kohn–Sham potential. Deutsche Mathematiker–Vereinigung, Jahrestagung 1996, Jena 15.–21. Sept. 1996.
- H. Wenzel, H.-Chr. Kaiser, R. Nürnberg, H. Gajewski, and H.-J. Wünsche. Towards 2d simulation of QW–lasers including the self–consistent solution of the Schrödinger equation. The 1996 Semiconductor Laser and Amplifier Workshop, Lillehammer, Norway, 19-21 September 1996.
- H.-Chr. Kaiser and J. Rehberg. Matching the phenomenological and the quantum mechanical description of semiconductor devices. Workshop on Phase Transitions: Microscopic and Mesoscopic Theory, Berlin, Germany, 2–7 June , 1997.