Analysis of solectron solutions in a dynamical lattice model

AG Thiele (Selbstorganisation und Komplexität), ITP, FB Physik, Universität Münster

Description
The project concerns the analysis of a one-dimensional lattice model that describes the interaction of the transport of electrons with the dynamics of the underlying crystal lattice. The interest in the onset of the motion of the coupled electrons/lattice excitations - the so-called solectrons. The model shall be investigated via time simulations and (most importantly) by numerical continuation.

The problem is of large conceptual interest as it further analyses a model that was introduced to propose a non-linear mechanism for high temperature superconductivity. A basic understanding of the model shall be reached and certain ‘holes’ in the published results shall be filled.

The project consists of

(i) Elements of physical modelling (understanding the structure of the coupled lattice model for the motion of the solectron).
(ii) Analytical and numerical treatment of the model with the aim of understanding the onset of the motion of solectrons.
(iii) Interpretation of the numerical results in terms of their physical implications.
(iv) Writing of a report that includes an appendix that can be used as a detailed computer tutorial for future students.

Options
Bachelor: (i) to (iv)
Master: no
Doctorate: no

Work includes
- Gaining an understanding of an existing model.
- Implementation of the model for time simulations to obtain starting solutions for the continuation (next point) - a simple Runge-Kutta should be sufficient.
- Implementation of the model using the numerical toolbox AUTO07p [based on continuation techniques to follow fixed points and limit cycles, Mac/Linux based fortran-code].
- Determination of travelling solutions and analysis of the resulting bifurcation diagrams.
- Usage of the implemented code(s), the analysis, discussion and presentation of the results.

Pre-conditions
- Experience with ODEs, PDEs, and their numerical solution would be helpful
- Basic concepts of bifurcation theory, linear stability analysis and/or hydrodynamics are appreciated
- Good working knowledge of basic tools of calculus and linear algebra
- Curiosity regarding the behaviour of real-world systems as described by the mathematical models of theoretical physics

Literature

Description
The project concerns the analysis of a spatially one-dimensional partial differential equation that represents one of the simplest models for the dynamics of a first order phase transition with a non-conserved order parameter (e.g., ordering transitions in binary alloys or wetting transitions for volatile liquids). The present project concerns an amended version of the model that accounts for a system where an alloy is moved through a heterogeneous temperature field, i.e., the phase transition occurs in a nonequilibrium setting, resulting in a rich spatio-temporal solution structure. This structure shall be investigated via numerical continuation and (optionally) by time simulations.

The project consists of

(i) Analytical and numerical treatment of the amended Allen-Cahn model with the aim of understanding the emergence of steady and time-periodic patterned states.
(ii) Interpretation of the numerical results in terms of their physical implications.
(iii) Writing of a report that includes an appendix that can be used as a detailed computer tutorial for future students.

Options
Bachelor: (i) to (iii)
Master: no
Doctorate: no

Work includes
- Gaining an understanding of an existing model.
- Implementation of the model using the numerical toolbox AUTO07p [based on continuation techniques to follow fixed points and limit cycles, Mac/Linux based fortran-code, detailed tutorials will be provided].
- Determination of steady state solutions and time-periodic states and analysis of the resulting bifurcation diagrams.
- (optional) Determination of linear stability of found steady state solutions.
- Usage of the implemented code(s), the analysis, discussion and presentation of the results.

Pre-conditions
- Experience with ODEs, PDEs, and their numerical solution would be helpful
- Basic concepts of bifurcation theory and linear stability analysis are appreciated
- Good working knowledge of basic tools of calculus and linear algebra
- Curiosity regarding the behaviour of real-world systems as described by the mathematical models of theoretical physics

Literature