Simulating convection with cellular automata

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Cellular automata (CA) can be used as an alternative access for modelling physical systems. The main advantage of CA’s is their simple structure. Moreover, roundoff errors are avoided since only integer numbers are used. The goal of this work will be to study subphotospheric convection.

A CA consists of a regular pattern of identical cells. Each cell can accept one of finite discrete states and the temporal evolution is also in discrete steps. A subsequent state of a cell is calculated using a rule that is valid for all other cells and only the cells in a defined neighborhood are considered affecting a cell. The calculation of a subsequent state first affects all cells at the present states and then applies to all new calculated states.

CA can be used to simulate gases. The particles move from one cell to another. According to the number of the neighbouring cells each particle can only have finite different velocities. Only a finite number of particles with different velocities can appear in one cell.

We developed three different models based on lattice gases for the simulation of the convection. The simplest model uses 6 velocities and 3 temperature states. This model describes convection of an incompressible fluid. The second model uses 19 velocities. This model describes the convection of a compressible fluid. These two models are twodimensional. The third model is a threedimensional extension of the first model with 12 velocities and 3 temperature states.

We simulated the convection of a fluid between two walls with different temperature. Convection begins after several thousand time steps. We derived the model equations for the three models. These equations are similar to the standard hydrodynamic equations for the convection.