Entropy, version 1.0, 2015-12-01

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The program illustrates the second law of thermodynamics, which states that the entropy of an isolated system not in equilibrium will increase with time. The system is modeled by a one-dimensional array of cells. Each cell contains a number of particles. For each time step and each particle, a random number is generated which controls if the particle moves to a neighboring cell.

The entropy S of a system is calculated according to statistical physics as

S=ln(W) with W=

Here, m is the number of cells, N is the total number of particles and the number of particles in cell i. Thus, W is the number of possible distributions of N particles into m cells with given ni, i=1,...,m.

Use the left and right arrow key to move the bold frame along the array of squares representing the cells. Press [v] or [↑] or [↓] to show a window containing the data of the cell. You can then change the number of particles in this cell or the type of the cell. There are three types: normal, fixed and insulated. Particles enter and leave freely a normal cell. Insulating cells don’t interact with their neighboring cells. Fixed cells contain a constant number of particles, but can absorb particles from or release them to other cells.

There are two modes of representation: “cells” and “line”. The “cells”-mode displays the number of particles in each cell as a bar above the cell. The “lines”-mode shows the maximum and minimum of particle numbers in the system as lines changing in time (time is represented by the step number).

Press the “Step”-button to calculate and display the next distribution. Particles move to the left or right or stay in their cell with probabilities 1/3 each. Entropy 1 shows the entropy before, Entropy 2 the entropy after the last step. You will see the entropy increase until a state of equilibrium is reached. The entropy will then fluctuate about a fixed value.

Key functions

“cells”-mode:

left and right arrow keys: move the bold frame along the array of cells

up and down arrow keys show data of marked cell

[v] show data of marked cell

[Tab] change highlighted button

[Enter] action highlighted button

[t] toggle between “cells” and “line” mode

[n] back to initial distributions

[+] increase vertical scale

[-] decrease vertical scale

“lines” mode:

[Tab] change highlighted button

[Enter] action highlighted button

[t] toggle between “cells” and “line” mode

[+] increase vertical scale

[-] decrease vertical scale

Data window:

[Tab] change cell type

up and down arrow keys change cell type

[Enter] accept changes, back to “cells”-mode

[Esc] return without changes

“Experiments”: If you start with an arbitrary distribution, leaving all cells in type normal, an approximately uniform distribution will appear in the course of time.

If you set the outmost left and right cell to fixed type with at least one value positive, and the other cells zero, a linear distribution will arise.

If you set one cell to a high value, leaving the others zero, the maximum will decline exponentially in time. You can interpret this as the decline of temperature of a hot spot in a cold environment.