**Investigating a simulation of free expansion of a gas: Prediction**

Below is a series of simulations of a hard-sphere gas under different conditions. Try to describe and explain the development of the system for each of the simulations. A picture of the initial state of the system is given in the upper left cell of each table; the black arrows represent the velocities of the particles.

1. **Gas without collisions, directed velocity**

Initial positions – The particles are randomly scattered in the left half of the container. Initial velocities – all the particles have equal velocities: fixed magnitude and upward direction. Collisions – no collisions, the particles pass through each other.

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| Initial state | *Micro (particle) description* | *Macro (system) description* | |
| **Animation**  (Dynamics and equilibrium) | **Graph of the average number of particles in the monitor vs. time: *N*(t)**  (Dynamics and equilibrium) | **Histogram of the average spreading of particle positions *N*(x)**  (in the equilibrium state) |
| **Describe** the development of the system and **schematically** sketch the graphs that you think will be found. |  |  |  |
| **Explain** why the system behaves as you described. |  |  |  |

1. **Gas with collisions, directed velocities**

Initial positions – The particles are randomly scattered in the left half of the container. Initial velocities – all the particles have equal velocities: fixed magnitude and upward direction. Collisions – The particles collide with each other with a fixed force.

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| Initial state | *Micro (particle) description* | *Macro (system) description* | |
| **Animation**  (Dynamics and equilibrium) | **Graph of the average number of particles in the monitor vs. time: *N*(t)**  (Dynamics and equilibrium) | **Histogram of the average spreading of particle positions *N*(x)**  (in the equilibrium state) |
| **Describe** the development of the system and **schematically** sketch the graphs that you think will be found. |  |  |  |
| **Explain** why the system behaves as you described. |  |  |  |

1. **Gas with no collisions, random velocities.**

Initial positions – The particles are randomly scattered in the left half of the container. Initial velocities – the particles’ velocities are random (magnitude and direction). Collisions – no collisions, the particles pass through each other.

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| Initial state | *Micro (particle) description* | *Macro (system) description* | |
| **Animation**  (Dynamics and equilibrium) | **Graph of the average number of particles in the monitor vs. time: *N*(t)**  (Dynamics and equilibrium) | **Histogram of the average spreading of particle positions *N*(x)**  (in the equilibrium state) |
| **Describe** the development of the system and **schematically** sketch the graphs that you think will be found. |  |  |  |
| **Explain** why the system behaves as you described. |  |  |  |