# The benchmark problems solved with a parallel version of G. A. Bird's DSMC

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Gefördert durch:

Bundesministerium
für Wirtschaft
und Technologie

aufgrund eines Beschlusses
des Deutschen Bundestages

eXIST
Existenzgründungen aus der Wissenschaft
Ein Programm des Bundesministeriums für Wirtschaft und Technologie

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# Outline

www.pi-dsmc.com

- Method of solution
- CPU time
- Results

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# Method of solution

**PI-DSMC:** The parallel and interactive DSMC software

DSMC
www.pi-dsmc.com

- Derived from Dr. G. A. Bird‘s state of the art codes
- Uses multiple CPUs on workstations and clusters
- Highly interactive via a DLL interface
- Universal, automatic mesh generation / adaption

# Method of solution

For p2 = 0, the orifice was an adsorbing surface. (1-5, 11-15)

Adsorbed molecules never return to reservoir 1

Adsorbed molecules trigger an event that can be recorded via the DLL interface. → No need to modify the main DSMC code

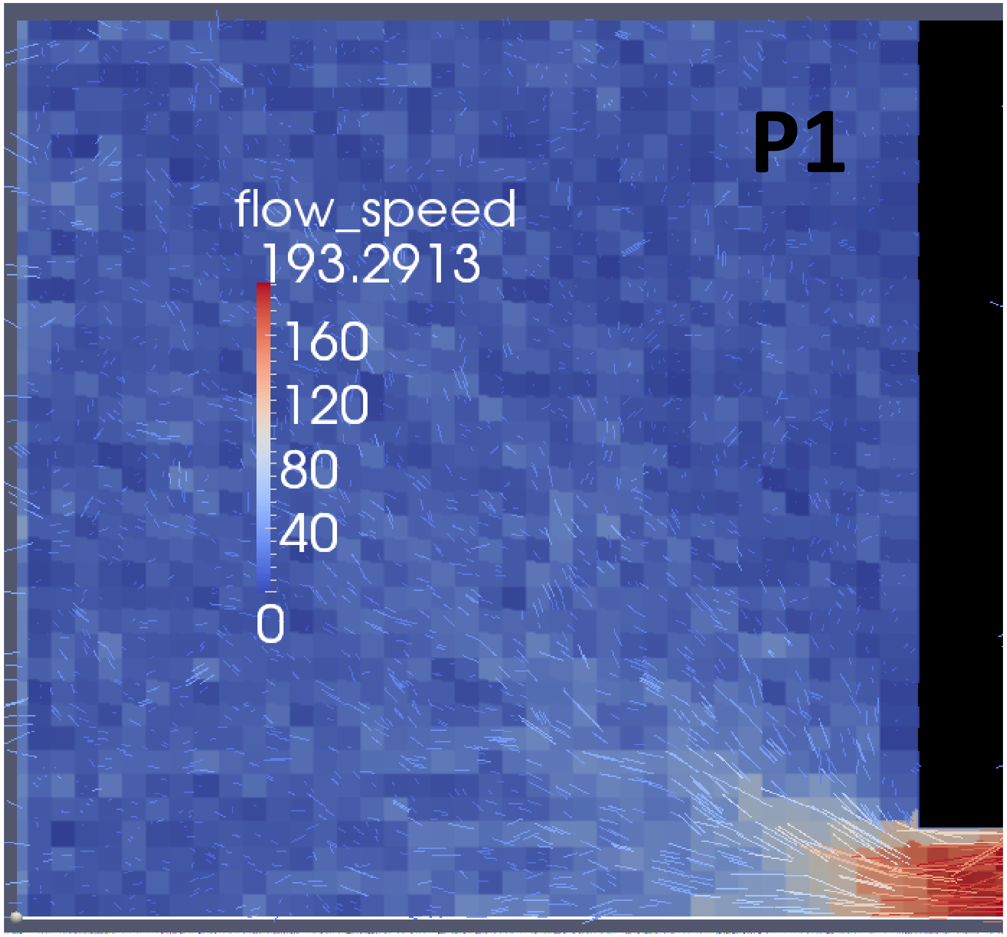
The mass flow rate is calculated from the **adsorption rate**

→ No flow from reservoir 2 to reservoir 1

→ Only the region of reservoir 1 was simulated

# Method of solution

Geometry for p2 = 0, L/H = 1



# Method of solution

For p2 > 0, the region of reservoir 1 and 2 was simulated

→ Flow from reservoir 2 to reservoir 1 is possible

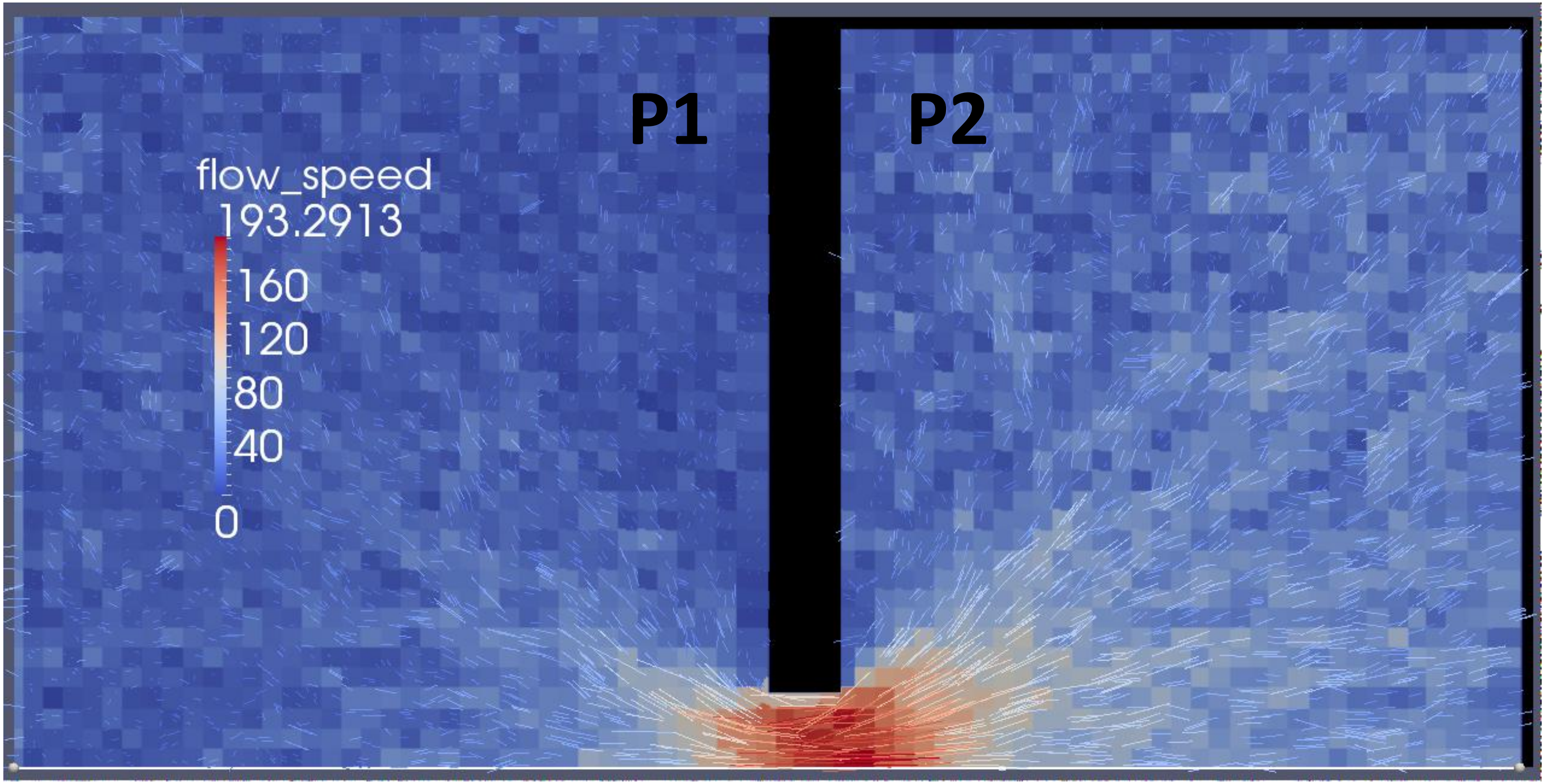
Mass flow rate obtained directly by **particle tracking**:

→ The DLL interface was used to compare the x-position of the particle before and after a move step.

→ If the particle crosses the orifice, the time of the event is recorded.

# Method of solution

Geometry for p2 > 0, L/H = 1



# CPU time

All simulations were performed on an AMD workstation:

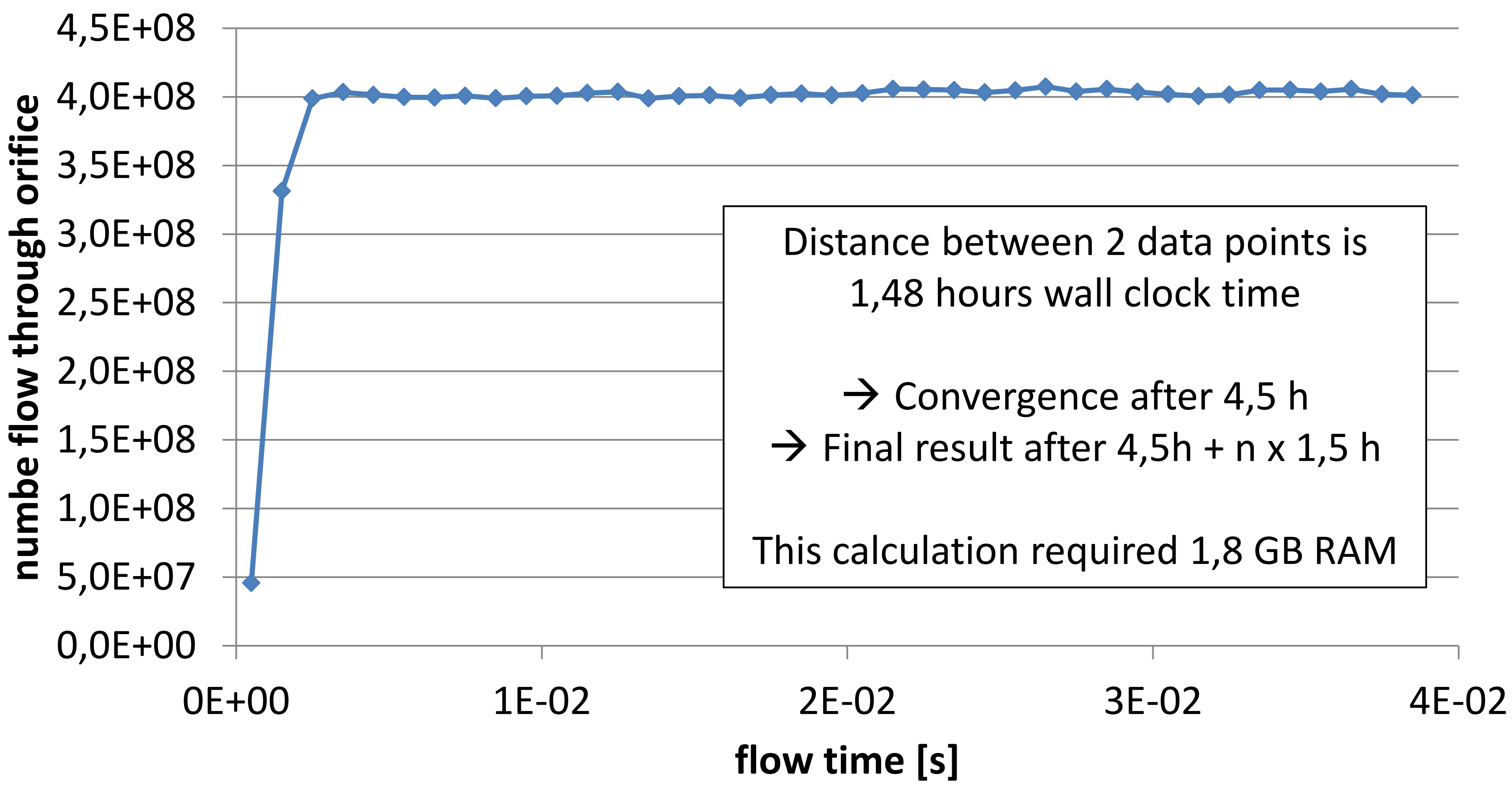
- dual socket AMD 6128, (2x8 cores @ 2GHz)
- 32 GB RAM, 600GB HDD raid 0

The time given in the abstract is the wall clock time required to calculate

- the steady state flow and
- 20 samples of the mass flow rate

# CPU time

How fast does the mass flow rate converge? (e.g. channel 20)



# Results - Channel

| Case | Reduced mass flow rate | Case | Reduced mass flow rate |
|---|---|---|---|
| 1 | **1.006 ± 1.26 % → theory** | 11 | 0.685 ± 1.28 % |
| 2 | 1.015 ± 0.95 % | 12 | 0.692 ± 0.76 % |
| 3 | 1.120 ± 0.45 % **- 2,4%** | 13 | 0.749 ± 0.43 % **- 2,2%** |
| 4 | 1.476 ± 0.22 % | 14 | 1.009 ± 0.17 % **- 2,3%** |
| 5 | 1.616 ± 0.37 % **+ 2,8%** | 15 | 1.331 ± 0.06 % **- 2,3%** |
| 6 | **0.501 ± 0.69 % → theory** | 16 | 0.402 ± 1.24 % **+ 16,8%** |
| 7 | 0.509 ± 0.81 % | 17 | 0.410 ± 0.79 % **+ 17,1%** |
| 8 | 0.602 ± 0.60 % **- 5,9%** | 18 | 0.479 ± 0.56 % **+ 14,5%** |
| 9 | 1.152 ± 0.45 % **- 7.1%** | 19 | 0.938 ± 0.55 % **+ 12,8%** |
| 10 | 1.328 ± 0.20 % **- 3.9%** | 20 | 1.327 ± 0.20 % **+ 1,8%** |

# Results - Tube

| Case | Reduced mass flow rate | Case | Reduced mass flow rate |
|---|---|---|---|
| 1 | **0.994 ± 0.58 % → theory** | 11 | 0.659 ± 0.66 % **- 2%** |
| 2 | 1.01 ± 0.34 % | 12 | 0.675 ± 0.26 % |
| 3 | 1.133 ± 0.24 % | 13 | 0.750 ± 0.40 % |
| 4 | 1.516 ± 0.27 % **+ 3,7%** | 14 | 1.058 ± 0.26 % |
| 5 | 1.560 ± 0.35 % **+ 1,7%** | 15 | 1.129 ± 0.27 % **- 17.5%** |
| 6 | **0.488 ± 1.22 % - 2,8%** | 16 | 0.349 ± 1.38 % **+ 3,5%** |
| 7 | 0.508 ± 0.78 % | 17 | 0.348 ± 1.17 % |
| 8 | 0.606 ± 0.84 % | 18 | 0.405 ± 0.67 % |
| 9 | 1.167 ± 0.41 % **- 1,7%** | 19 | 0.847 ± 0.37 % **- 2,2%** |
| 10 | 1.252 ± 0.36 % **- 6,8%** | 20 | 1.201 ± 0.47 % **- 6,9%** |

# The end

Higher precision calculations will be performed by the end of June. Results will be posted on www.pi-dsmc.com

Thanks a lot for your attention!