Lattice Boltzmann simulation of phase separation in liquid - vapour systems

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Lattice Boltzmann evolution equation:

$$\partial_t f_i + e_{i\beta}\partial_\beta f_i = \frac{1}{\chi c^2} f_i^{eq}(e_{i\beta} - u_\beta)F_\beta - \frac{1}{\tau}(f_i - f_i^{eq}), \qquad i = 0, 1, \dots, 8$$

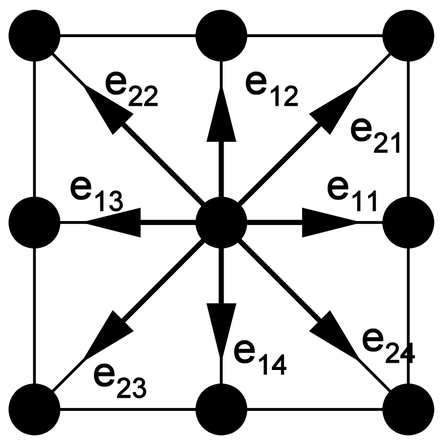
density: $n = \sum_i f_i$ velocity: $u_\beta = \frac{1}{n}\sum_i f_i\, e_{i\beta}$

force term : $F_\beta = \frac{1}{n}\partial_\beta\left(p^i - p^w\right) + \kappa\partial_\beta(\nabla^2 n)$

ideal gas pressure : $p^i = \theta n$

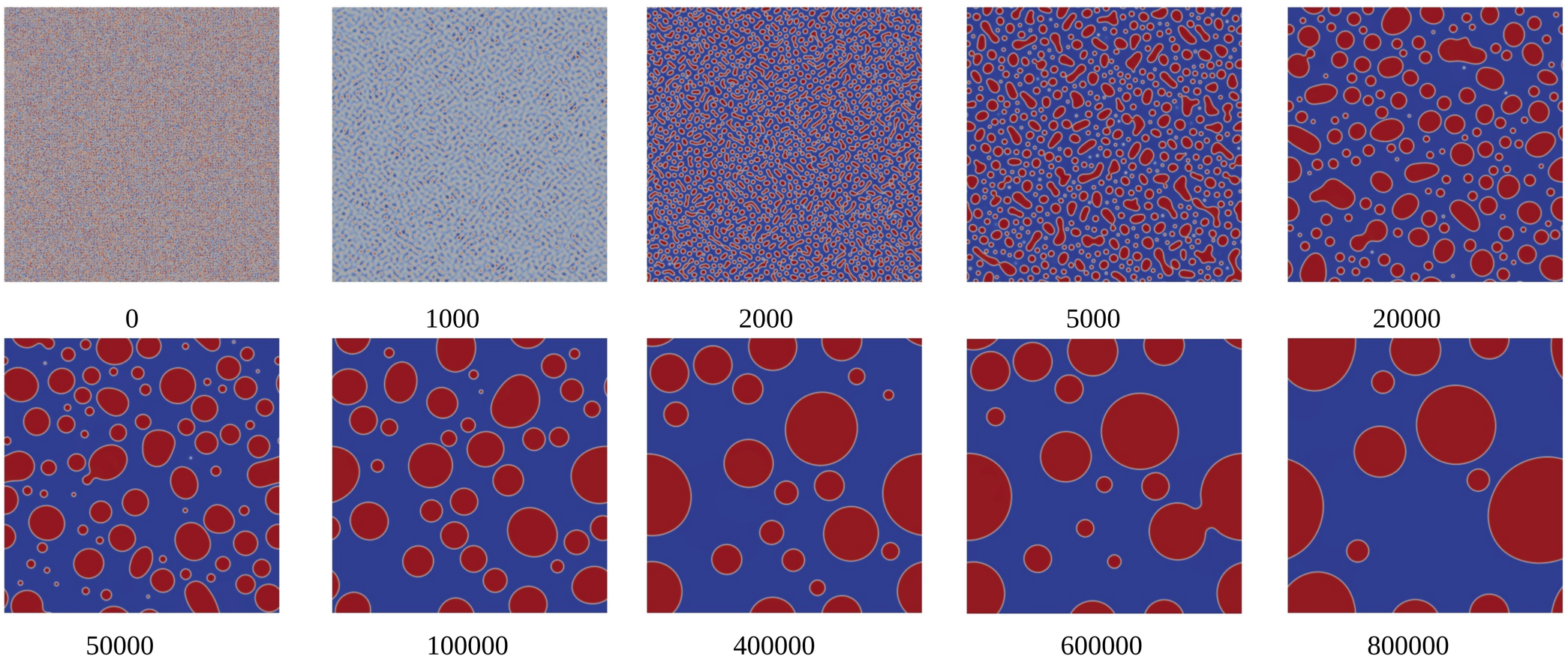
van der Waals gas pressure: $p^w = \frac{3\theta n}{3-n} - \frac{9}{8}n^2$

discrete velocity set



equilibrium distribution function :

$$f_i^{eq} = w_i n\left[1 + \frac{e_i \cdot u}{\chi c^2} + \frac{(e_i \cdot u)^2}{2\chi c^4} - \frac{(u)^2}{2\chi c^2}\right]$$



evolution of liquid – vapour phase separation at $\theta = 0.85$ on a 2D lattice with 1024 x 1024 nodes

Blue Gene / P

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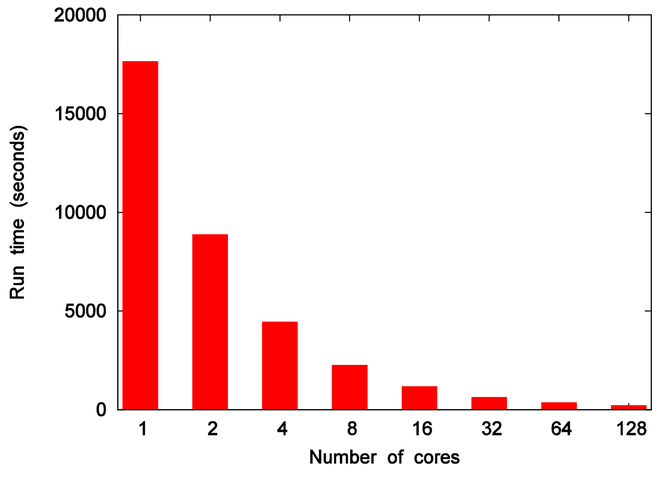

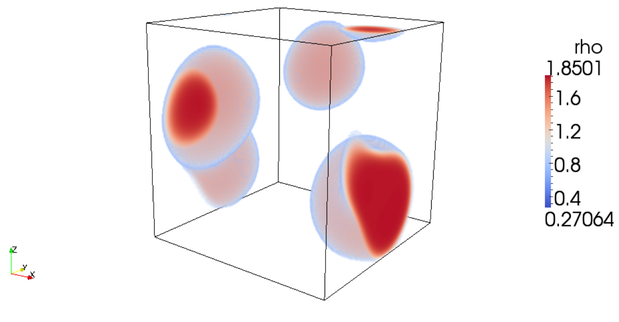

phase separation on a 3D lattice
128 x 128 x 128 nodes