Lattice Boltzmann models for van der Waals fluids

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Lattice Boltzmann evolution equation :

$$\partial_t f_i + \xi_{i\beta}\partial_\beta f_i = -\frac{1}{\tau}\left(f_i - f_i^{eq}\right) + F_i$$

$$i = 1, 2, \ldots, Q^2$$

$$f_i^{eq} = \omega_i \sum_{n=0}^{N} \frac{1}{n!}\mathcal{H}^{(n)}(\boldsymbol{\xi}_i)\boldsymbol{a}^{(n)}(\boldsymbol{x}, t)$$

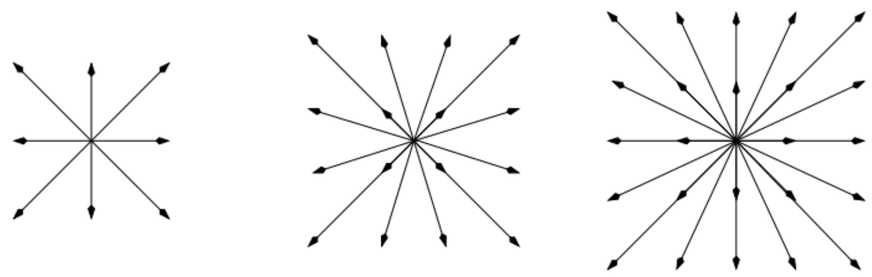
$$\boldsymbol{a}^{(n)}(\boldsymbol{x}, t) = \sum f_i(\boldsymbol{x}, t)\mathcal{H}^{(n)}(\boldsymbol{\xi}_i)$$

Case A : $$F_i = \omega_i \sum_{n=1}^{N} \frac{1}{n!}\mathcal{H}^{(n)}(\boldsymbol{\xi}_i)\boldsymbol{g}\boldsymbol{a}^{(n-1)}$$

Case B : $$F_i = \frac{1}{\theta}\boldsymbol{g}\cdot(\boldsymbol{\xi}_i - \boldsymbol{u}_i)f_i^{eq}$$

$$\boldsymbol{g} = \nabla(p^i - p^w)$$

$$p^i = n\theta \qquad p^w = \frac{3\theta n}{3-n} - \frac{9}{8}n^2$$

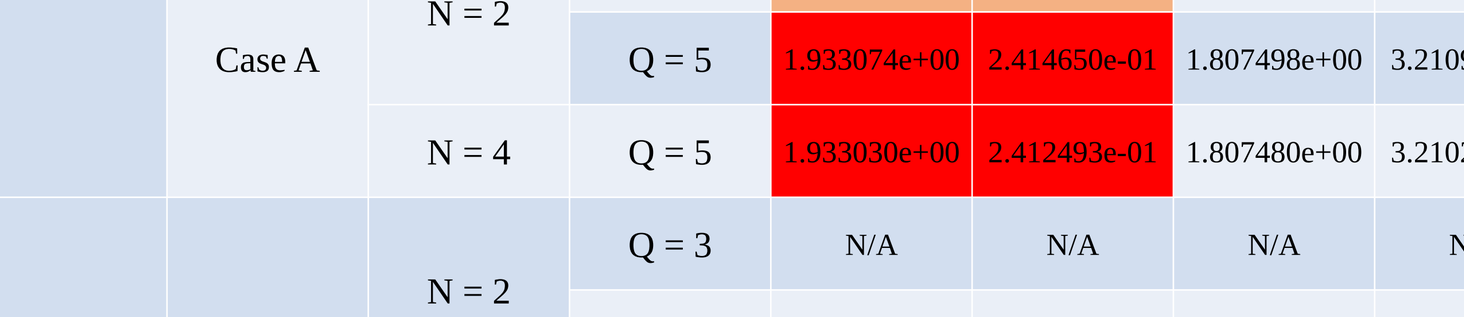


Q = 3 Q = 4 Q = 5

velocity sets

Gauss – Hermite Lattice Boltzmann Models

				T = 0.80		T = 0.85		T = 0.90		T = 0.95	
				q_L	q_V	q_L	q_V	q_L	q_V	q_L	q_V
Maxwell construction				1.932703e+00	2.396669e-01	1.807141e+00	3.197300e-01	1.657271e+00	4.257417e-01	1.461727e+00	5.790150e-01
HLB $\tau = 10^{-3}$	Case B	N = 2	Q = 3	1.934271e+00	2.474222e-01	1.808550e+00	3.251578e-01	1.658437e+00	4.291537e-01	1.462472+00	5.805760e-01
			Q = 5	1.934158e+00	2.468517e-01	1.808435+00	3.247099e-01	1.658332e+00	4.288415e-01	1.462398e+00	5.804200e-01
		N = 4	Q = 5	1.934149e+00	2.468036e-01	1.808431e+00	3.246914e-01	1.658330e+00	4.288367e-01	1.462398e+00	5.804195e-01
	Case A	N = 2	Q = 3	1.933249e+00	2.423250e-01	1.807688e+00	3.218203e-01	1.657777e+00	4.272144e-01	1.462080e+00	5.797513e-01
			Q = 5	1.933074e+00	2.414650e-01	1.807498e+00	3.210924e-01	1.657603e+00	4.267052e-01	1.461960e+00	5.795009e-01
		N = 4	Q = 5	1.933030e+00	2.412493e-01	1.807480e+00	3.210216e-01	1.657597e+00	4.266883e-01	1.461960e+00	5.794991e-01
HLB $\tau = 10^{-2}$	Case A	N = 2	Q = 3	N/A	N/A	N/A	N/A	N/A	N/A	1.468957e+00	5.953527e-01
			Q = 5	1.946610e+00	3.226993e-01	1.819466e+00	3.741814e-01	1.667128e+00	4.575770e-01	1.467758e+00	5.924451e-01
		N = 4	Q = 5	1.946647e+00	3.229817e-01	1.819480e+00	3.742532e-01	1.667131e+00	4.575195e-01	1.467758e+00	5.924453e-01
	Case B	N = 2	Q = 3	N/A	N/A	N/A	N/A	N/A	N/A	1.465488e+00	5.871699e-01
			Q = 5	1.939927e+00	2.782454e-01	1.813200e+00	3.444000e-01	1.661840e+00	4.395996e-01	1.464293e+00	5.845031e-01
		N = 4	Q = 5	1.939493e+00	2.757842e-01	1.813006e+00	3.435006e-01	1.661770e+00	4.393920e-01	1.464277e+00	5.844677e-01



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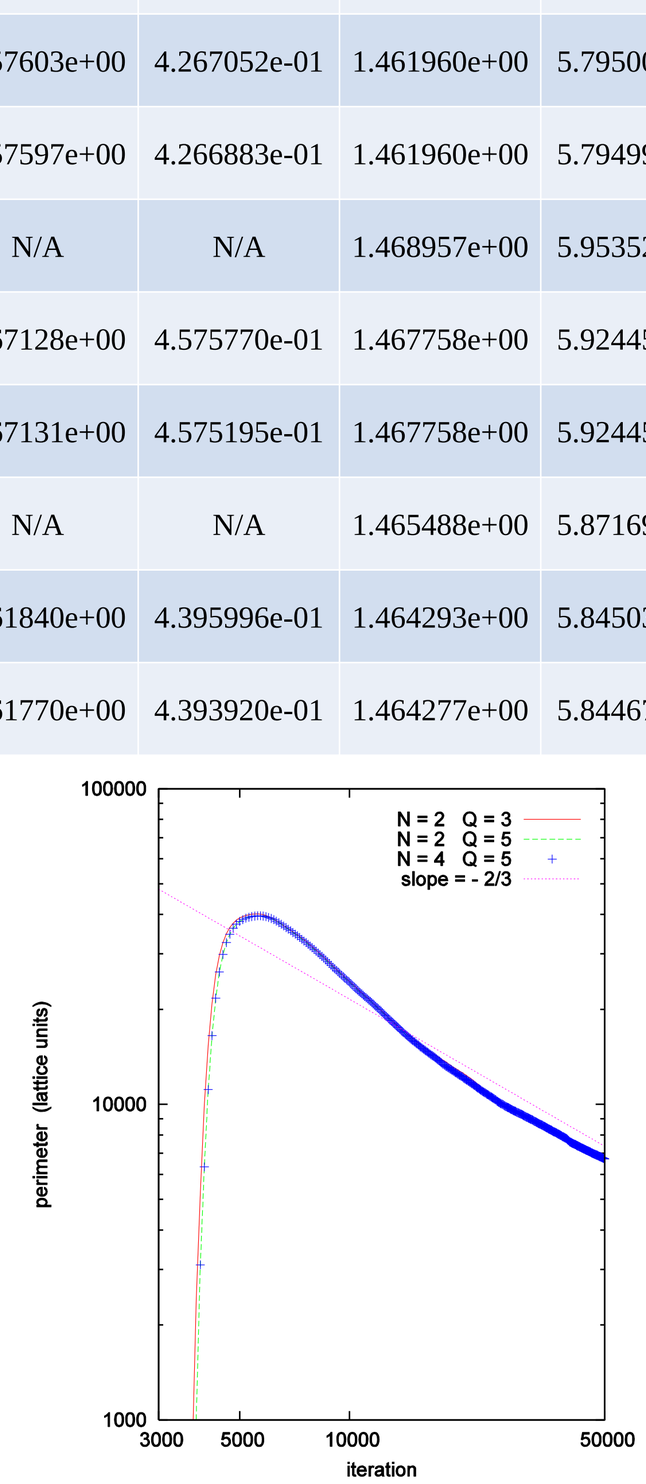
100000 350000 400000 700000 1200000



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