Facultad de Ciencias, Departamento Física
Universidad Nacional de Colombia - Sede Bogotá

Lattice- Boltzmann para fluidos immiscibles.

Juan Guillermo Acosta
Juan Sebastian Florez

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FLUIDOS
- Miscibilidad

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- Resultados

- La capacidad de mezlarse y formar compuestos homogéneos.
- Una propiedad tanto de fluidos como de gases.
- Si bien pueden ser solubles en cierta proporción, la miscibilidad implica que lo sea en todas sus proporciones.

Distribución de densidad:

$$f_i\left(\mathbf{x},t\right) = f_i^R\left(\mathbf{x},t\right) + f_i^B\left(\mathbf{x},t\right)$$

Colisionador:

$$f_i^\sigma\left(\mathbf{x}+\mathbf{c}_\mathrm{i},t+1\right) = f_i^\sigma\left(\mathbf{x},t\right) + \Omega_i^\sigma\left(\mathbf{x},t\right)$$

Operadores Colisión

$$\Omega_i^\sigma\left(\mathbf{x},t\right) = \Omega 3_i^\sigma\left\{\Omega 1_i^\sigma + \Omega 2_i^\sigma\right\}$$

$$\Omega 1_i^\sigma = -\frac{1}{\tau^\sigma}\left(f_i^\sigma - f_i^{\sigma(e)}\right)$$

$$\Omega 1_i^\sigma = -\omega^\sigma \left(f_i^\sigma - f_i^{\sigma(e)} \right)$$

Funciones de equilibrio:

$$f_0^{\sigma(e)} = \rho^\sigma \left(\alpha^\sigma - \frac{2}{3}\mathbf{u}^2 \right) \qquad (i=0)$$

$$f_i^{\sigma(e)} = \rho^\sigma \left(\frac{1-\alpha^\sigma}{5} + W_i \left[3\mathbf{c}_i \cdot \mathbf{u} + \frac{9}{2}(\mathbf{c}_i \cdot \mathbf{u})^2 - \frac{3}{2}\mathbf{u}^2 \right] \right), \quad (i=1,2,3,4)$$

$$f_i^{\sigma(e)} = \rho^\sigma \left(\frac{1-\alpha^\sigma}{20} + W_i \left[3\mathbf{c}_i \cdot \mathbf{u} + \frac{9}{2}(\mathbf{c}_i \cdot \mathbf{u})^2 - \frac{3}{2}\mathbf{u}^2 \right] \right), \quad (i=5,6,7,8)$$

Funciones de peso:

$$W_i = \begin{cases} \frac{4}{9}, & (i=0) \\ \frac{1}{9}, & (i=1,2,3,4) \\ \frac{1}{36}, & (i=5,6,7,8) \end{cases}$$

Funciones de densidad:

$$\rho^{\sigma} = \sum_{i} f_i^{\sigma} = \sum_{i} f_i^{\sigma(e)}$$

Momentum:

$$\rho\mathbf{u} = \sum_{i}\sum_{\sigma} f_i^{\sigma}\mathbf{c}_{\mathbf{i}} = \sum_{i}\sum_{\sigma} f_i^{\sigma(e)}\mathbf{c}_{\mathbf{i}}$$

Gradiente de densidad:

$$\mathbf{F}(\mathbf{x}) = \sum_{i=1}^{8} \mathbf{c}_i \left[\rho^R (\mathbf{x} + \mathbf{c}_i) - \rho^B (\mathbf{x} + \mathbf{c}_i) \right]$$

Operador Colision 2:

$$\Omega 2_i^{\sigma} = \frac{A^{\sigma}}{2} |\mathbf{F}| \left[W_i \frac{(\mathbf{c}_i \cdot \mathbf{F})^2}{|\mathbf{F}|^2} - B_i \right]$$

Parámetros del colisionador:

$$B_i = \begin{cases} -\dfrac{4}{27} & (i=0) \\ \dfrac{2}{27} & (i=1,2,3,4) \\ \dfrac{5}{108} & (i=5,6,7,8) \end{cases}$$

Re-Coloreo:

$$f_i^{R'} + f_i^{B'} = f_i^{'}$$

$$\sum_i f_i^{R'} = \rho^R$$

Función de relajación:

$$\omega = \begin{cases} \omega^R, & \psi > \delta, \\ f^R(\psi), & \delta \geq \psi > 0, \\ f^B(\psi), & 0 \geq \psi \geq -\delta, \\ \omega^B & \psi < -\delta \end{cases}$$

$$f^R(\psi) = \beta + \gamma\psi + \varepsilon\psi^2$$

$$f^B(\psi) = \beta + \eta\psi + \xi\psi^2$$

Parámetros de relajación:

$$\beta = \langle \omega \rangle$$

$$\gamma = \frac{2\left(\omega^R - \beta\right)}{\delta}$$

$$\varepsilon = -\frac{\gamma}{2\delta}$$

$$\eta = \frac{2\left(\beta - \omega^B\right)}{\delta}$$

$$\xi = \frac{\eta}{2\delta}$$

$$\langle \omega \rangle = \frac{2\omega^R \omega^B}{\omega^R + \omega^B}$$

SIMULACIÓN

Deformación de una gota cuadrada de un fluido dentro de otro.

- Se utiliza una rejilla cuadrada (128x128).
- Se ajustan las condiciones de frontera para dos fluidos, dispuestos como un cuadrado inmerso dentro de otro ($\rho = 1$).

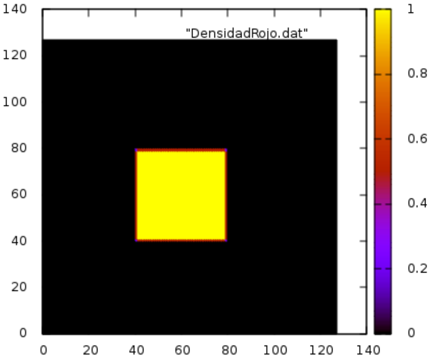

Figure: t=0, Lx=128, Ly=128, Lado=40

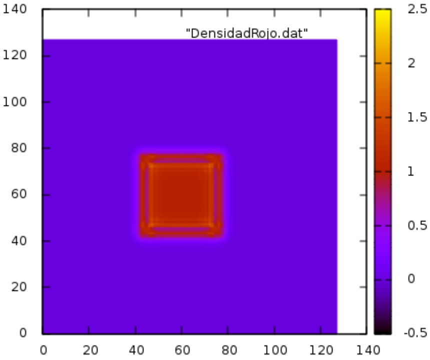

Figure: t=10, Lx=128, Ly=128, Lado=40

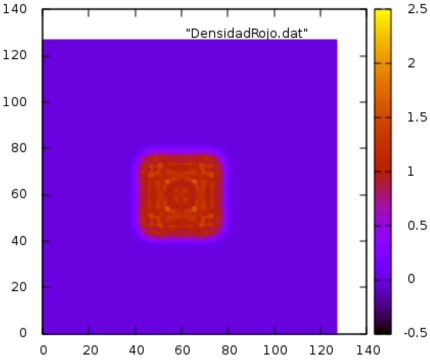

Figure: t=50, Lx=128, Ly=128, Lado=40

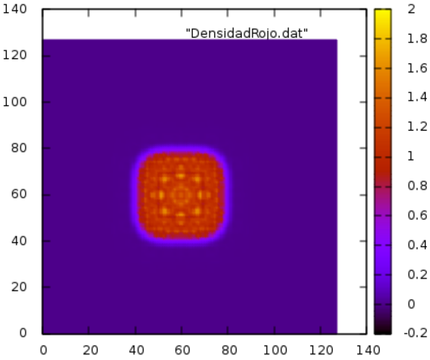

Figure: t=100, Lx=128, Ly=128, Lado=40

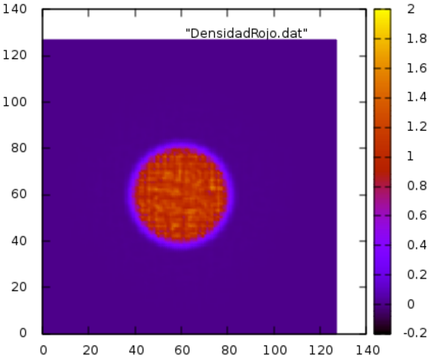

Figure: t=400, Lx=128, Ly=128, Lado=40

Resultados

Gota Cuadrada en dos fases, razón de densidad $\rho_b/\rho_r = 5$

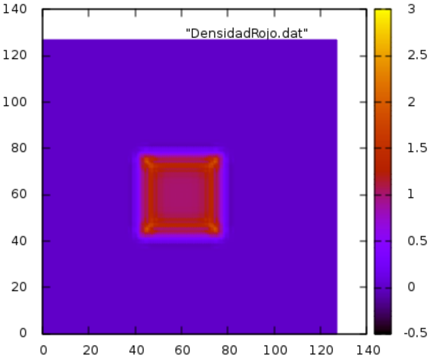

Figure: t=10, Lx=128, Ly=128, Lado=40

Resultados

Gota Cuadrada en dos fases, razón de densidad $\rho_b/\rho_r = 5$

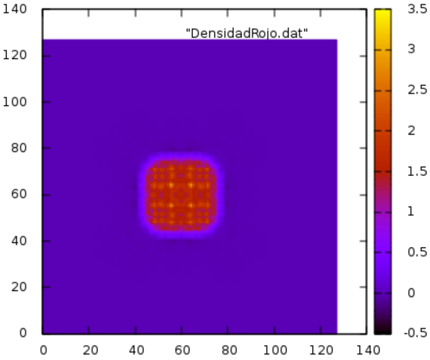

Figure: t=100, Lx=128, Ly=128, Lado=40

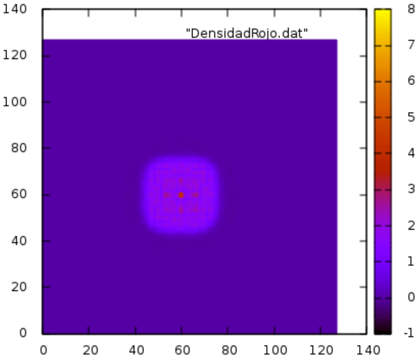

Figure: t=150, Lx=128, Ly=128, Lado=40

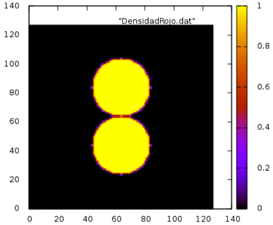

Figure: t=0, Lx=128, Ly=128, Radio=20

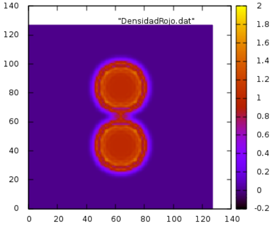

Figure: t=10, Lx=128, Ly=128, Radio=20

Dos Gotas
Resultados

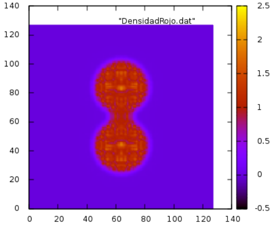

Figure: t=50, Lx=128, Ly=128, Radio=20

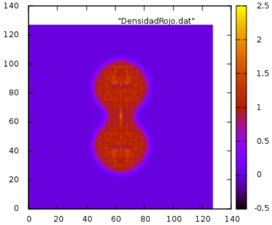

Figure: t=100, Lx=128, Ly=128, Radio=20

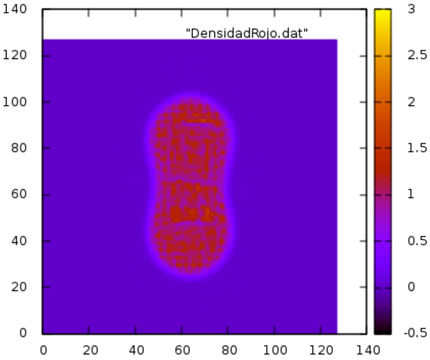

Figure: t=400, Lx=128, Ly=128, Radio=20

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