1 Organelle transport with no motors

1.1 Viscous media

Our starting point is the one-dimensional Langevin equation that describes the time evolution of an organelle,

$$\gamma_0 \dot{x}(t) = \xi_0(t), \tag{1}$$

where $x(t)$ is the position of the organelle (also here referred as cargo), γ_0 is the viscosity of the media, and $\xi_0(t)$ is a Gaussian random noise, here referred as white noise, and which represents the effect of the collisions with the molecules. $\xi_0(t)$ has a Gaussian probability distribution with correlation function

$$\langle \xi(t)\xi(t') \rangle = k_B T \gamma_0 \delta(t - t'). \tag{2}$$

The viscosity of the media γ_0 is determined by the Stokes, as $\gamma_0 = 6\pi R\eta$, where η is the viscosity of the media, and r_o is the radious of the cargo.

This model represents a purely viscous fluid, in which the resulting cargo displays a diffusive dynamic. Diffusive dynamics are characterized by a Mean Square Disaplacement (MSD) that sastisfies MSD$\sim \Delta t$, in short- and long-term scales. In the models here included we consider $r_o = 500$ nm y $k_B T = 4.1$ pNnm.

1.2 Viscoelastic media

In order to include viscoelastic properties that may result in subdifussice regimes, we includes elastic forces between the cargo and i virtual particles described by $x_j(t)$, $j = 1 \cdots N$. In this way, we consider the effect of cellular crowding. Hence, the movement equation can be written as

$$\gamma_0 \dot{x}(t) = -\sum_{j=0}^{N-1} k_j (x(t) - x_j(t)) + \xi_0(t), \tag{3}$$

where k_j is the elastic constant associated to the interaction between the cargo and the j virtual particled. Simultaneously, virtual particles satisify the Langevin equations

$$\eta_j \dot{x}_j(t) = k_j (x(t) - x_j(t)) + \xi_j(t), \tag{4}$$

where η_j is the effective viscosity on the virtual particle j, and the noise $\xi_j(t)$ satisfy

$$\langle \xi_i(t)\xi_j(t') \rangle = k_B T \delta(t - t')\delta_{ij}. \tag{5}$$

By defining the frequency and viscosity of the particle i as in:

$$\eta_i = \frac{\gamma_0}{\Gamma(1-\alpha)} \frac{\nu_0^\alpha}{b^{i\alpha}}, \qquad \nu_i = \frac{\nu_0}{b^i}, \tag{6}$$

where ν_0 is the maximum frequency, and $b > 1$ is a scale paremeter, the equations (4-6) can be rewritten as

$$\text{MSD} \sim (\Delta t)^\alpha \qquad \text{para} \qquad \frac{1}{\nu_0} < \Delta t < \frac{1}{\nu_{N-1}}, \tag{7}$$

$$\text{MSD} \sim \Delta t \qquad \text{para} \qquad \frac{1}{\nu_{N-1}} < \Delta t. \tag{8}$$

The values assigned to ν_0 and N generate mixed regimes where, the cargo describes a sub-diffusive dynamic at short time scales, and a diffusive dynamic at long timescales. Figure 1 illustrates an example of a mixed regime with a sub-diffusive dynamics of the cargo in $10^{-5}s < \Delta t < 10^{-2}$s, but diffusive at $10^{-2}s < \Delta t$ when $N = 8$, and $\nu_0 = 10^6\text{s}^{-1}$, $b = 5$.

Observar que para valores de ν_0 y N suficientemente grandes, la ley de potencia que resulta es MSD$\sim (\Delta t)^\alpha$ a toda escala. En este caso, las eqs (3) y (4) constituyen una aproximación markoviana para la Ecuación Generalizada de Langevin

$$\gamma_0 = \xi_0(t) + \int_0^\infty \gamma(t-t')\dot{x}(t') + \xi_\gamma(t), \tag{9}$$

con

$$\gamma(t) = \frac{\gamma_0}{\Gamma(1-\alpha)t^{-\alpha}}, \tag{10}$$

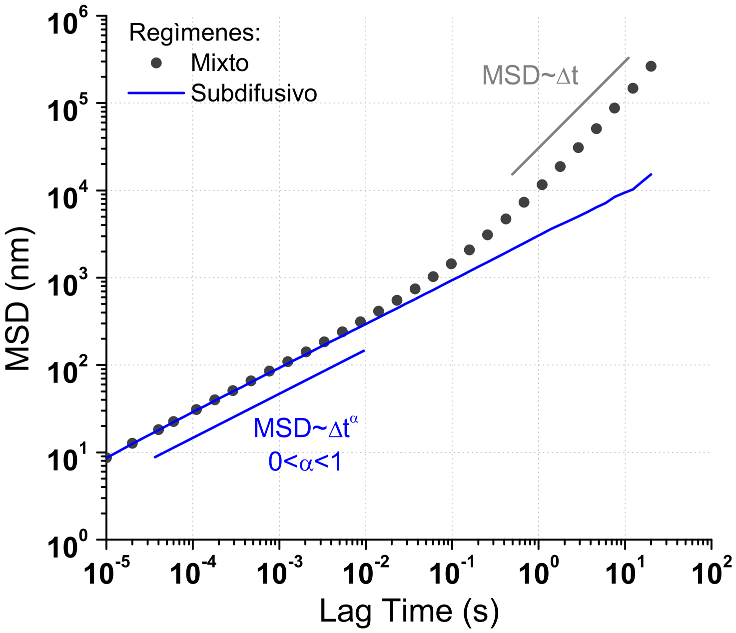

Figure 1: MSD in mixed regimes as a result of eqs. (3) y (4)