

# 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,

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

where  $x(t)$  is the position of the organelle (also here referred as cargo),  $\gamma_0$  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

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

The viscosity of the media  $\gamma_0$  is determined by the Stokes, as  $\gamma_0 = 6\pi R\eta$ , where  $\eta$  is the viscosity of the media, and  $r_o$  is the radius 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 Displacement (MSD) that satisfies  $\text{MSD} \sim \Delta t$ , in short- and long-term scales. In the models here included we consider  $r_o = 500$  nm y  $k_B T = 4.1$  pNm.

## 1.2 Viscoelastic media

In order to include viscoelastic properties that may result in sub-diffusive 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

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

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

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

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

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

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

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

where  $\nu_0$  is the maximum frequency, and  $b > 1$  is a scale parameter, the equations (4-6) can be rewritten as

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

$$\text{MSD} \sim \Delta t \quad \text{para} \quad \frac{1}{\nu_{N-1}} < \Delta t. \quad (8)$$

The values assigned to  $\nu_0$  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  $10^{-5} \text{s} < \Delta t < 10^{-2} \text{s}$ , but diffusive at  $10^{-2} \text{s} < \Delta t$  when  $N = 8$ , and  $\nu_0 = 10^6 \text{s}^{-1}$ ,  $b = 5$ .

With  $\nu_0$  and  $N$  large enough, the resulting mean square displacement satisfies  $\text{MSD} \sim (\Delta t)^\alpha$  in all time scales. In this case, equations (3) and (4) are considered as the Markovian approximation of the Generalized Langevin Equation (GLE).

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

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

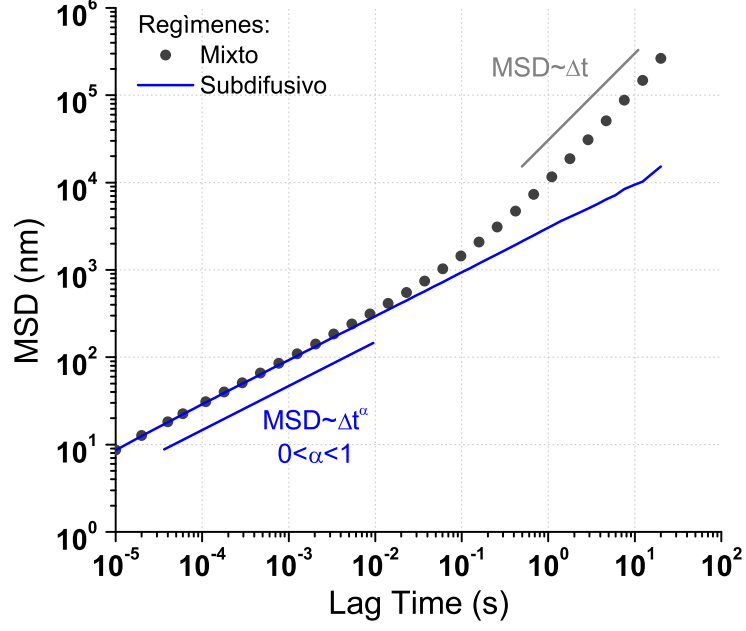


Figure 1: MSD in mixed regimes as a result of eqs. (3) y (4)