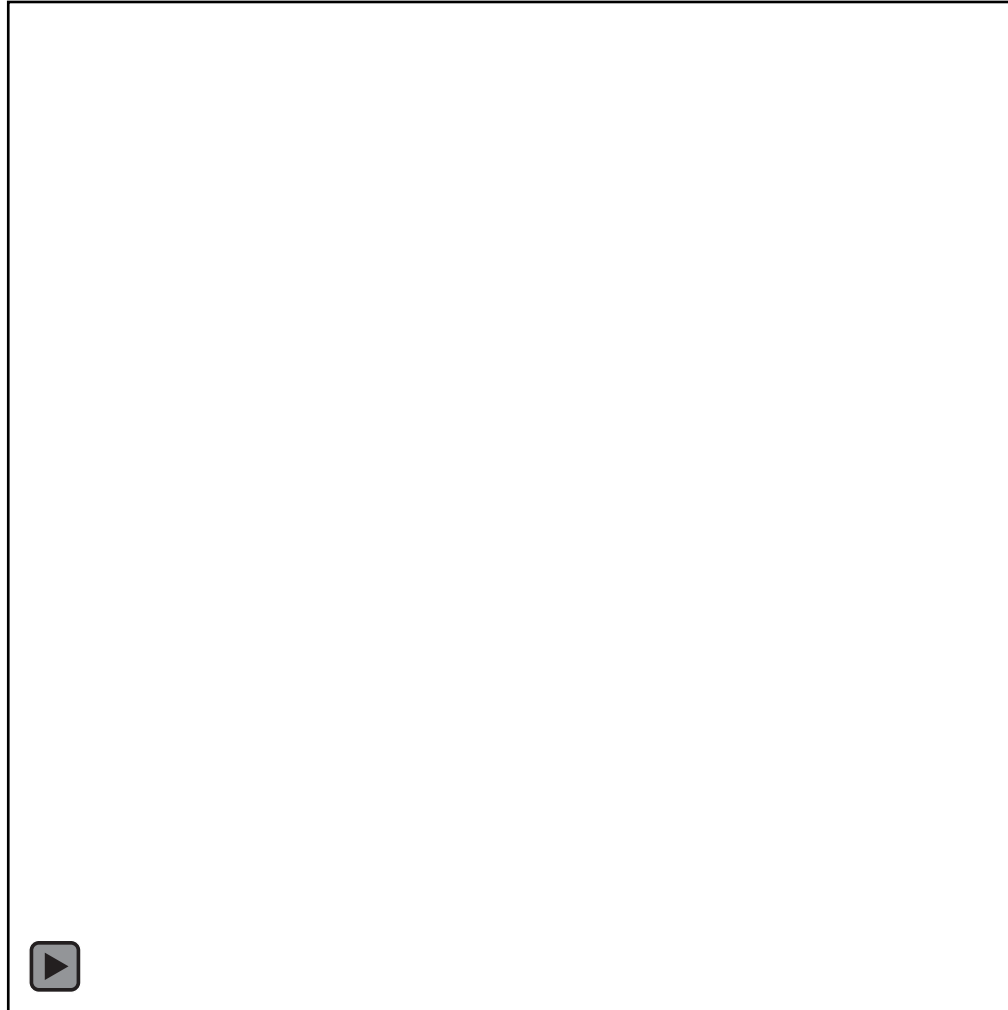


2012.10.30
物性物理学C

ブラウン運動とLangevin方程式

ブラウン運動

ナノ粒子



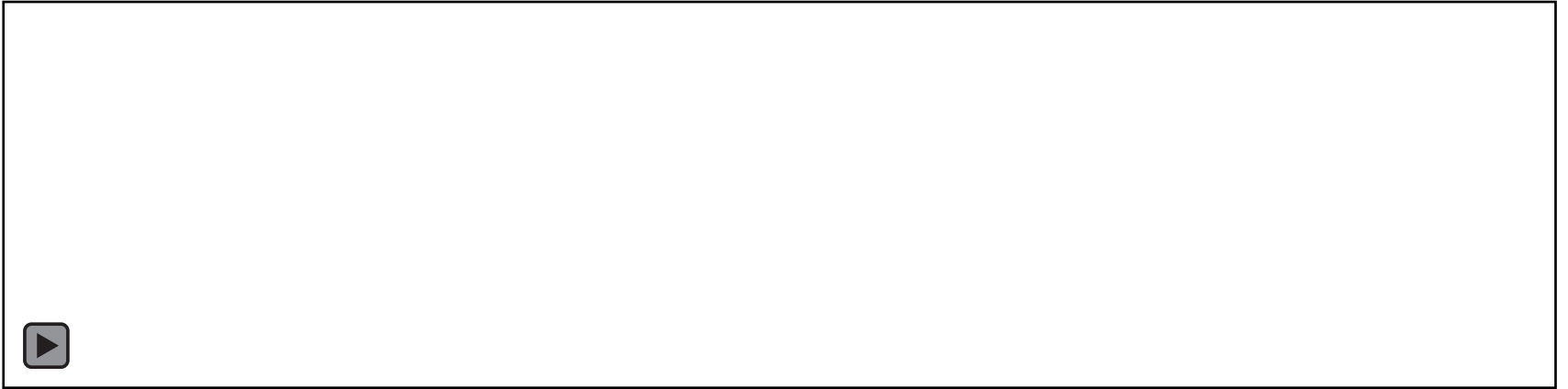
Langevin方程式

$$m \frac{d^2 \mathbf{r}}{dt^2} = -k \frac{d\mathbf{r}}{dt} + \xi(t)$$

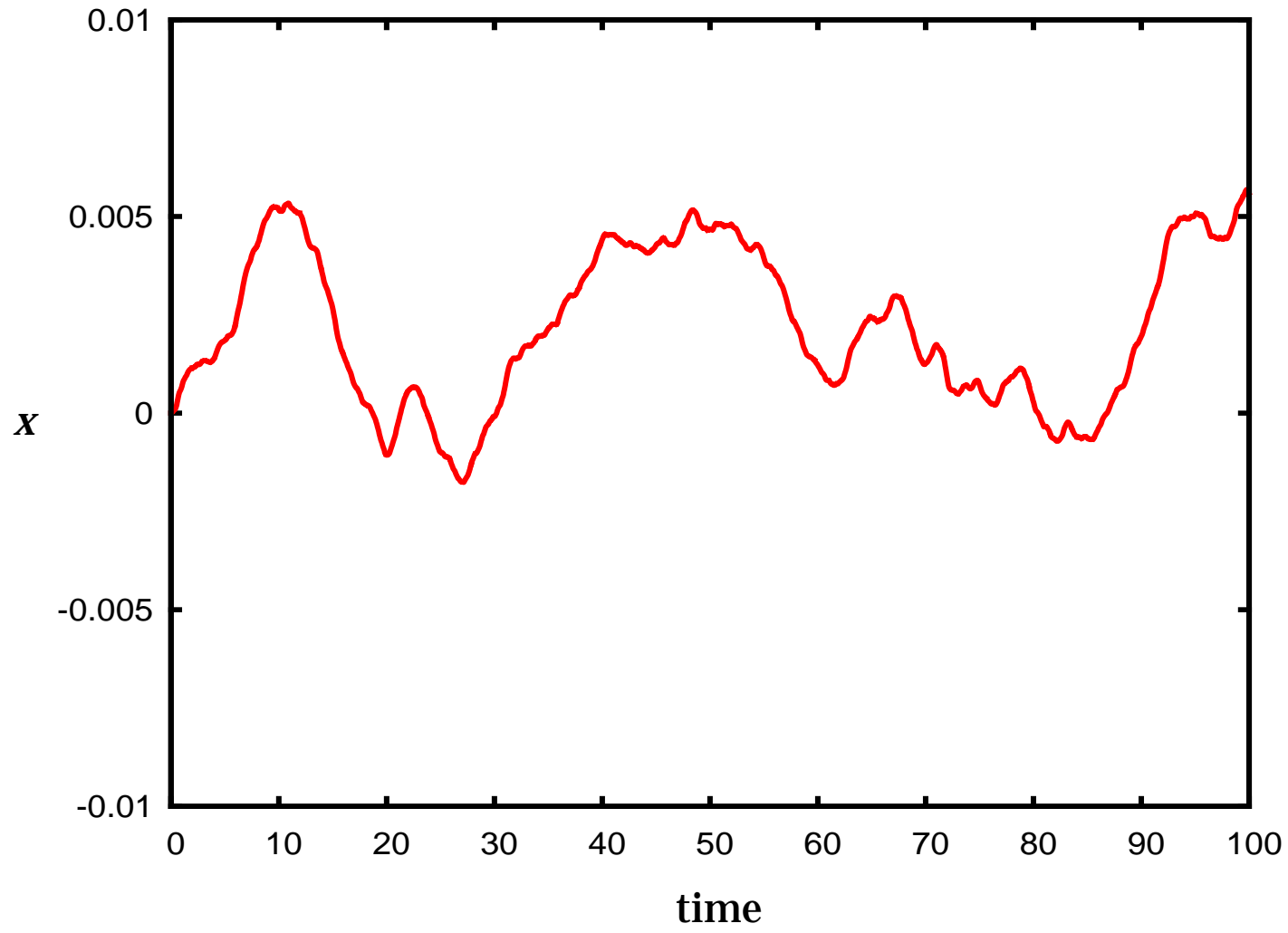
$$\langle \xi(t) \rangle = 0$$

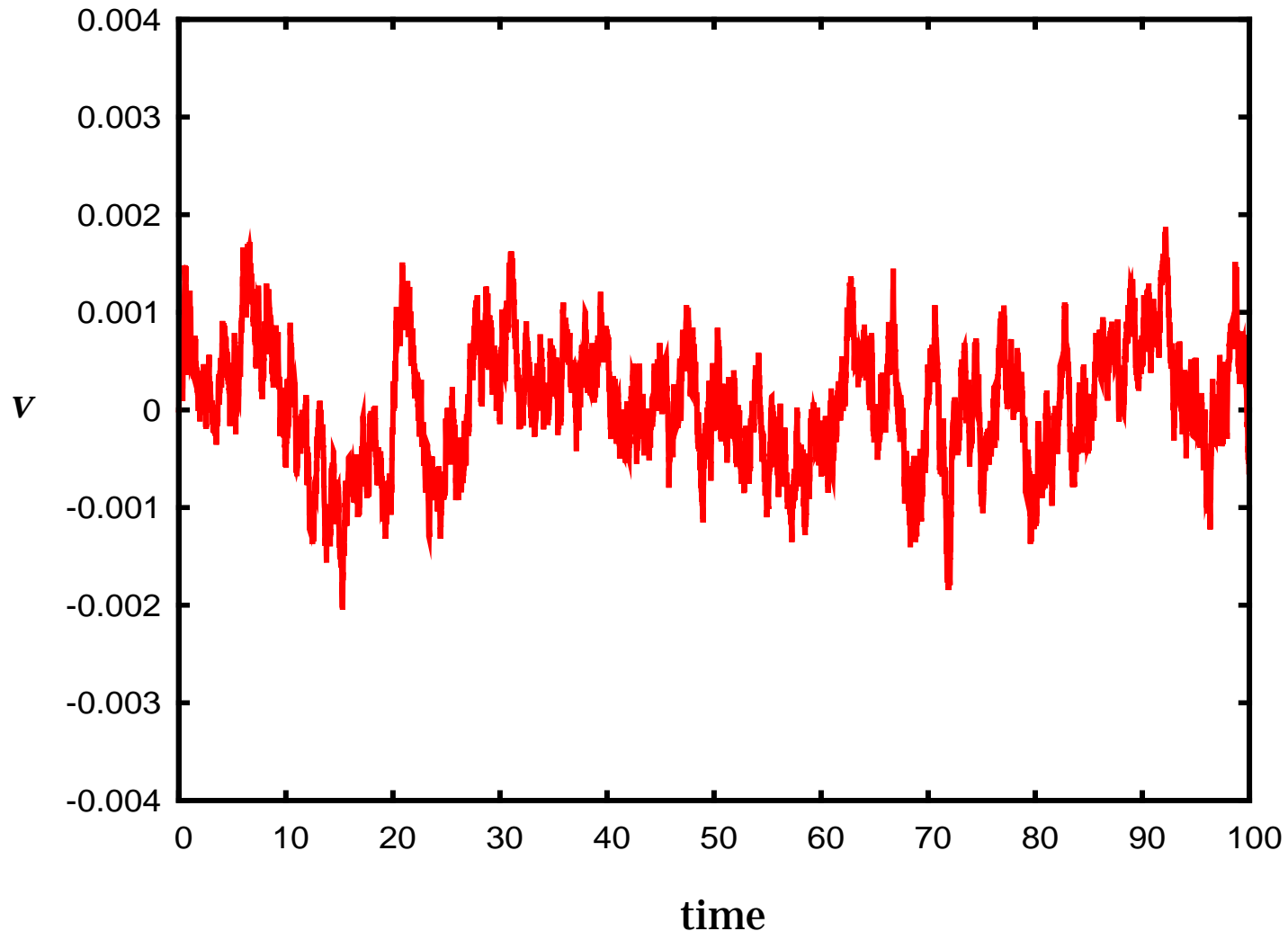
$$\langle \xi(t) \cdot \xi(s) \rangle = 2M\delta(t-s)$$

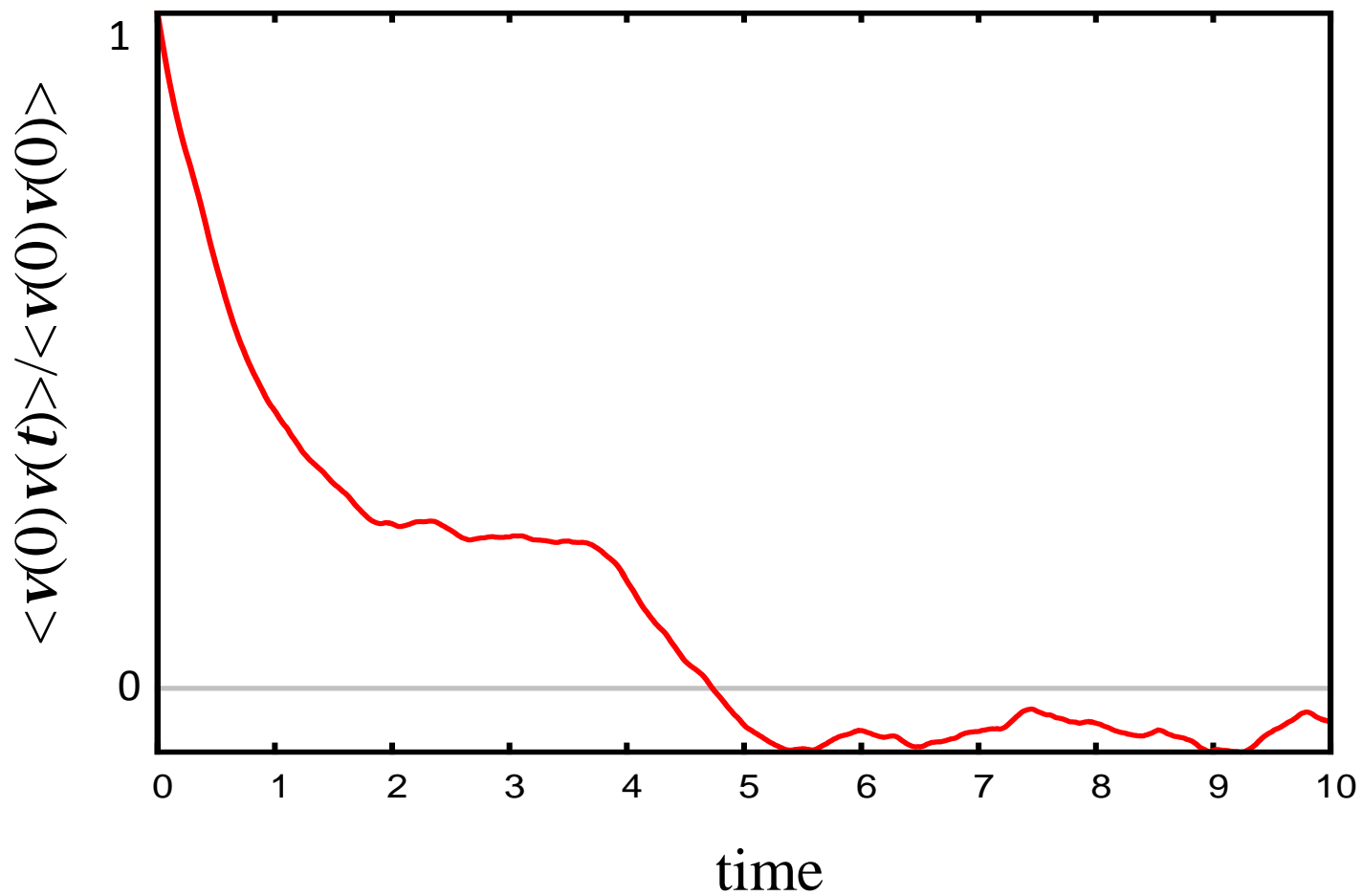
1次元系でのLangevin方程式による挙動



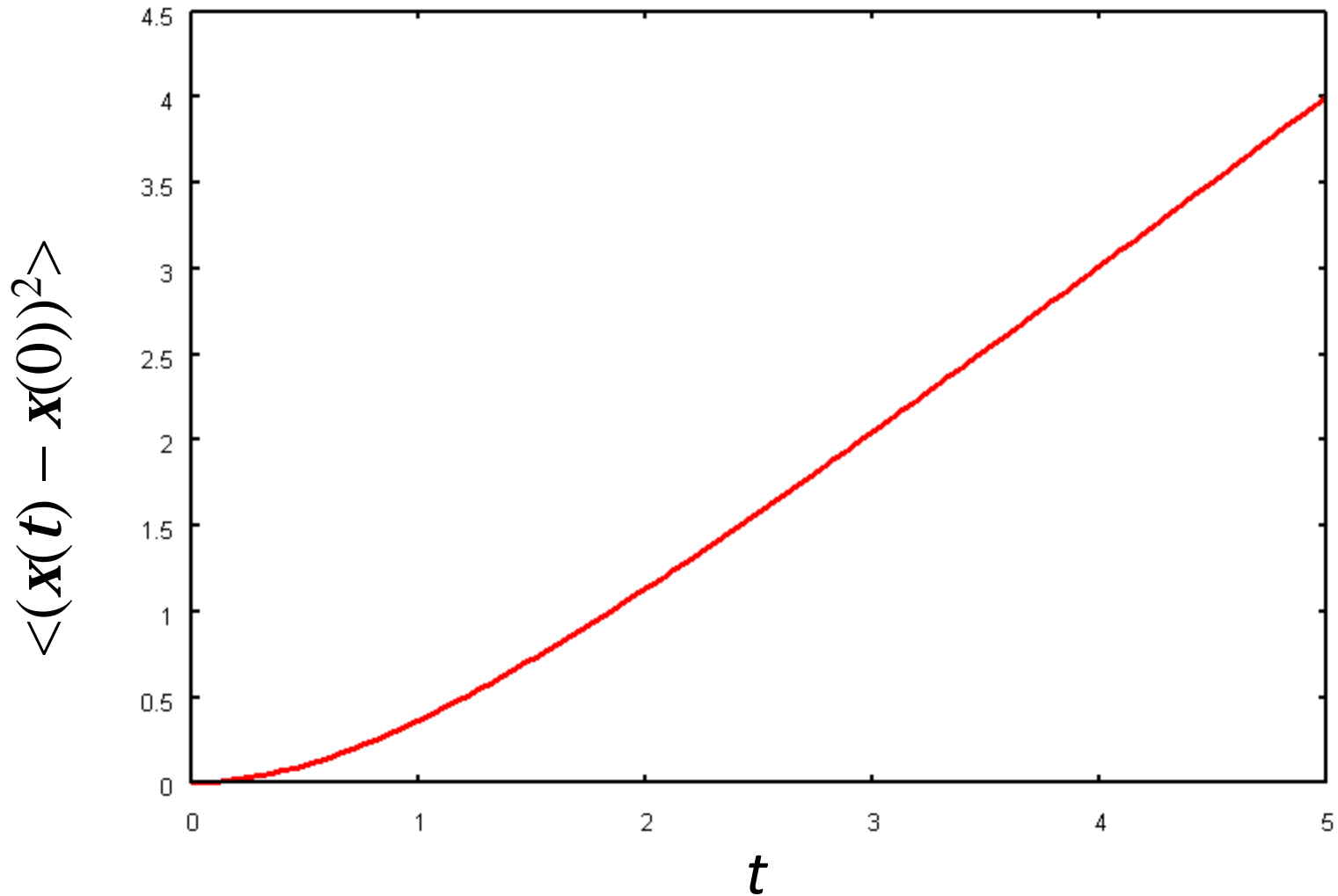
x





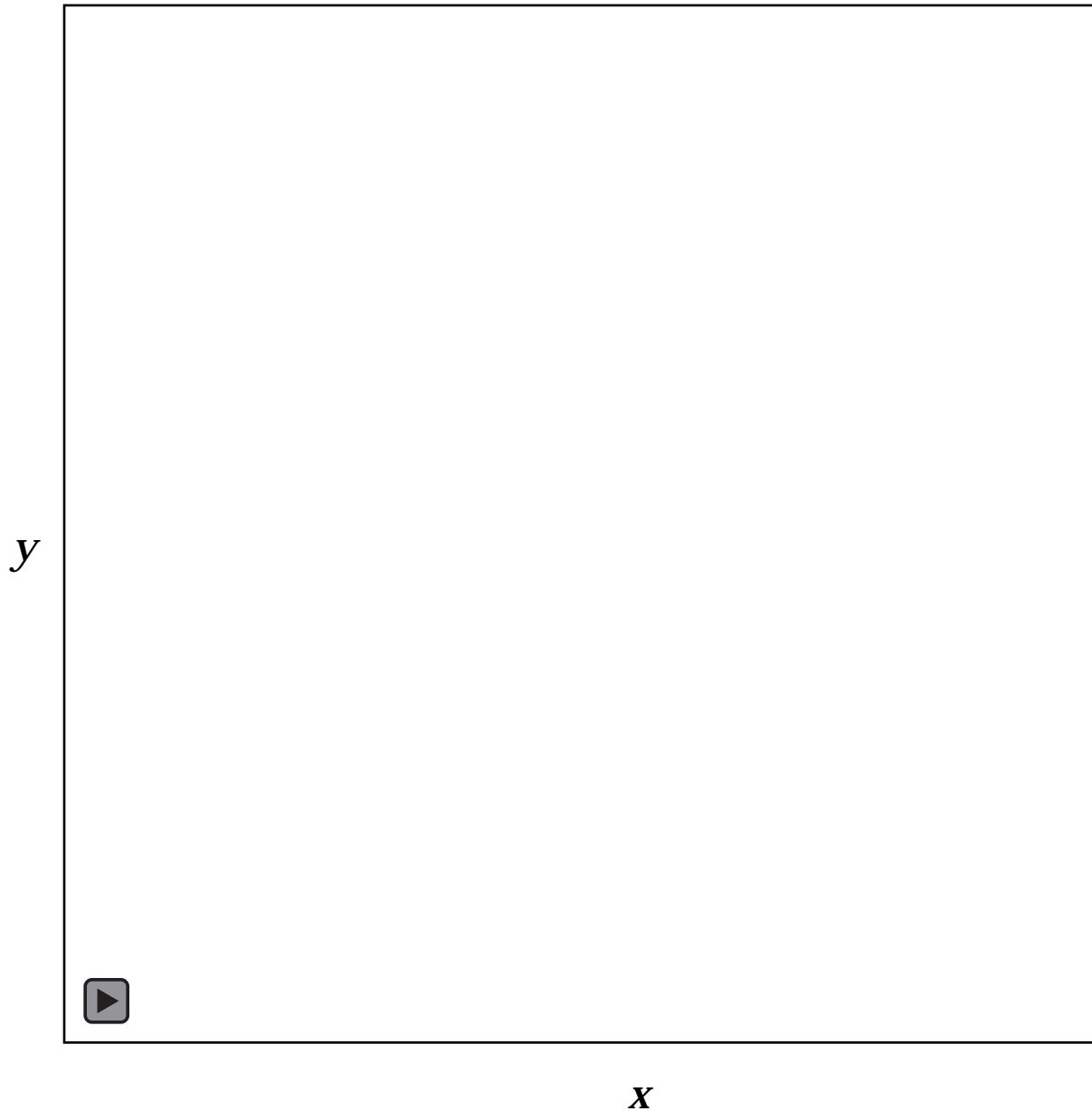


$$\langle v(0)v(t) \rangle / \langle v(0)v(0) \rangle \propto \exp(-t/\tau)$$



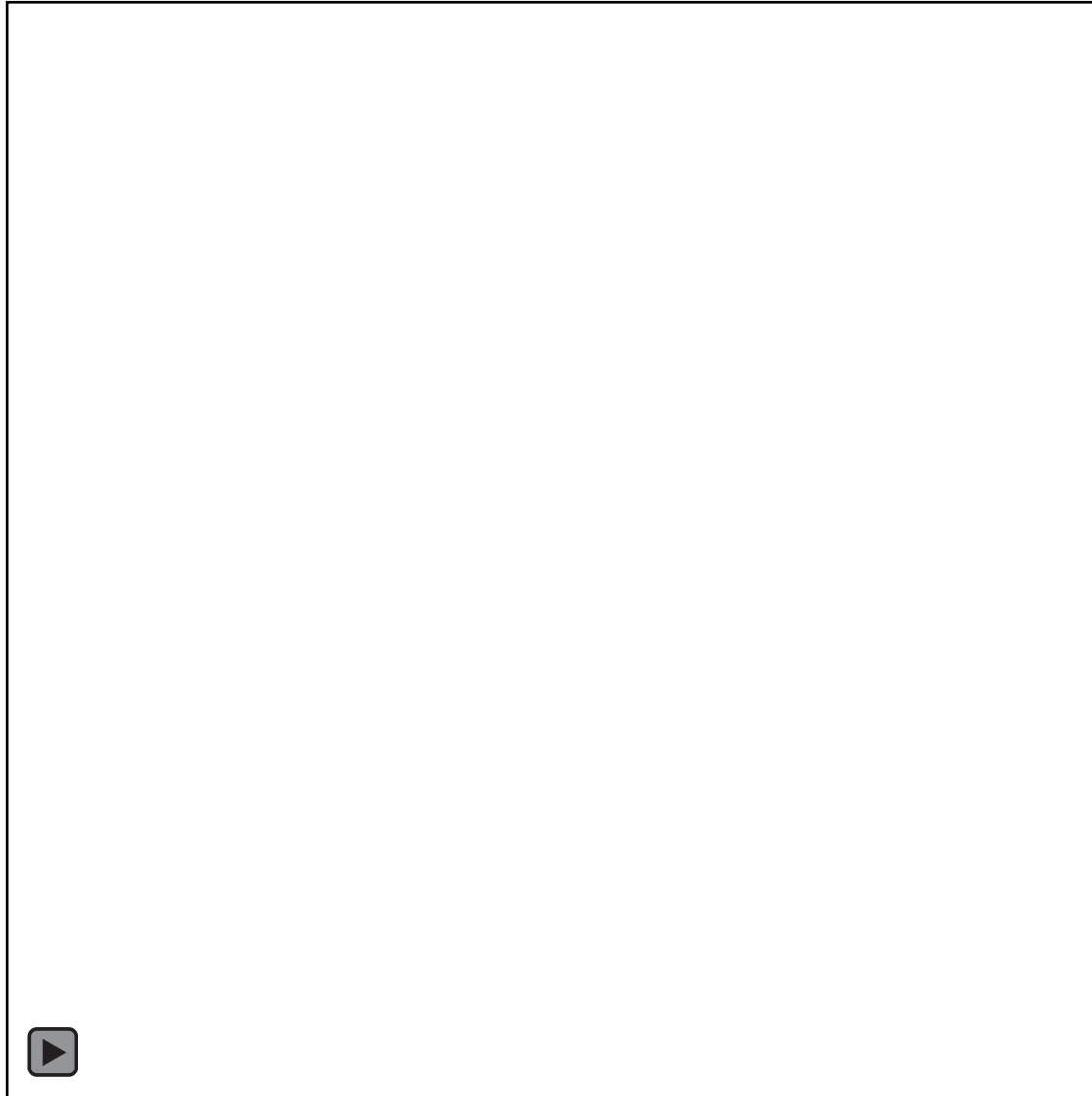
$$\langle (\mathbf{x}(t) - \mathbf{x}(0))^2 \rangle = (2Mt/\gamma) [t - (m/\gamma) \exp(-\gamma t/m)]$$

2次元での数値計算



軌跡を残すと

y



x