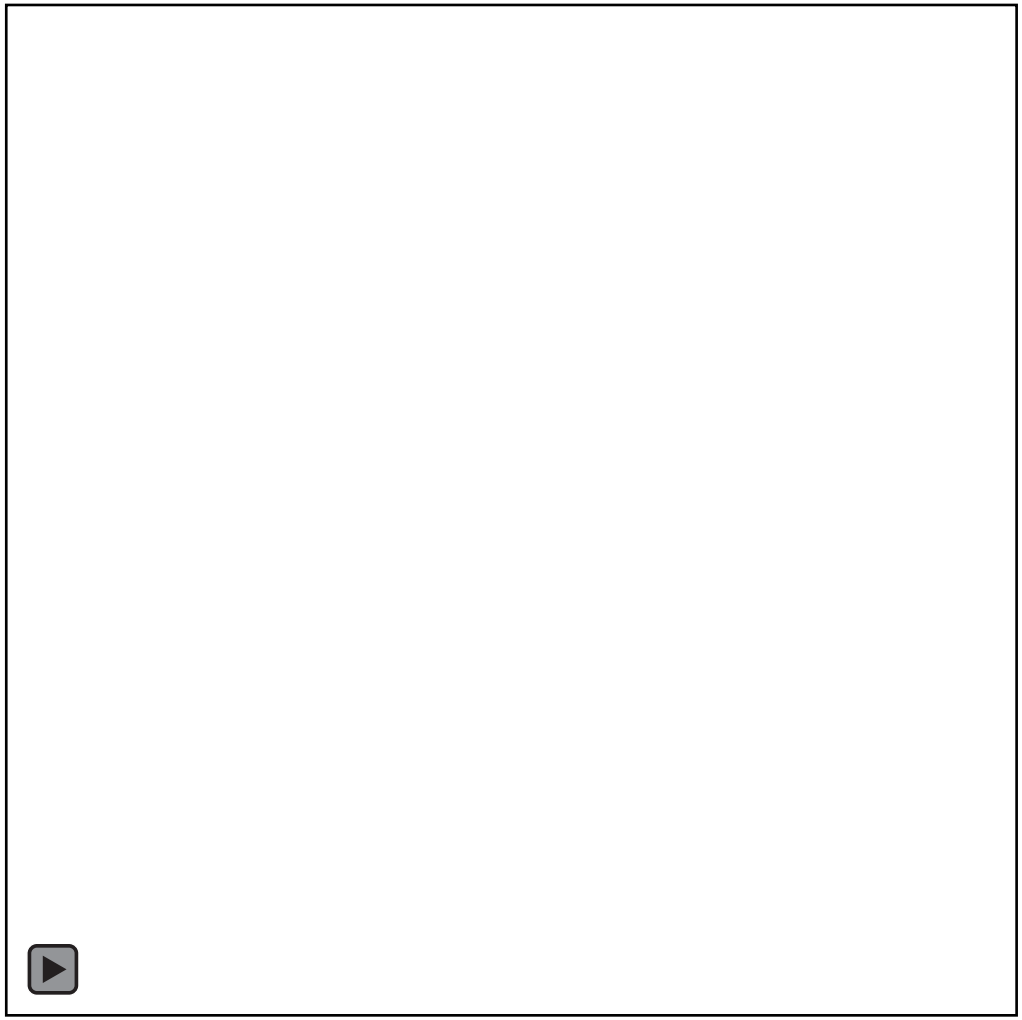
2013.10.29
物性物理学C

ブラウン運動とLangevin方程式

ブラウン運動

ナノ粒子



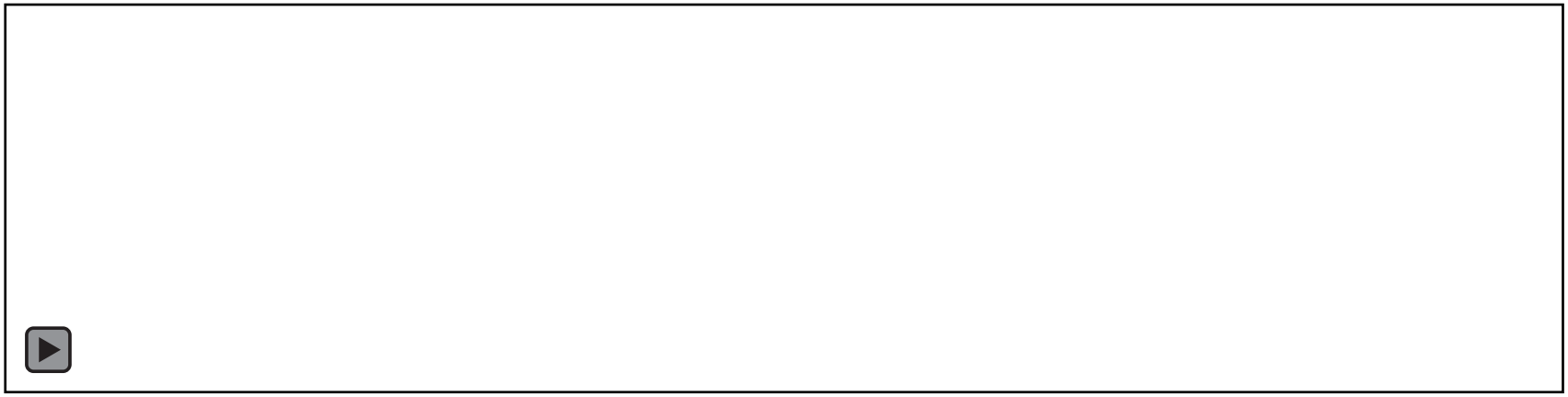
Langevin方程式

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

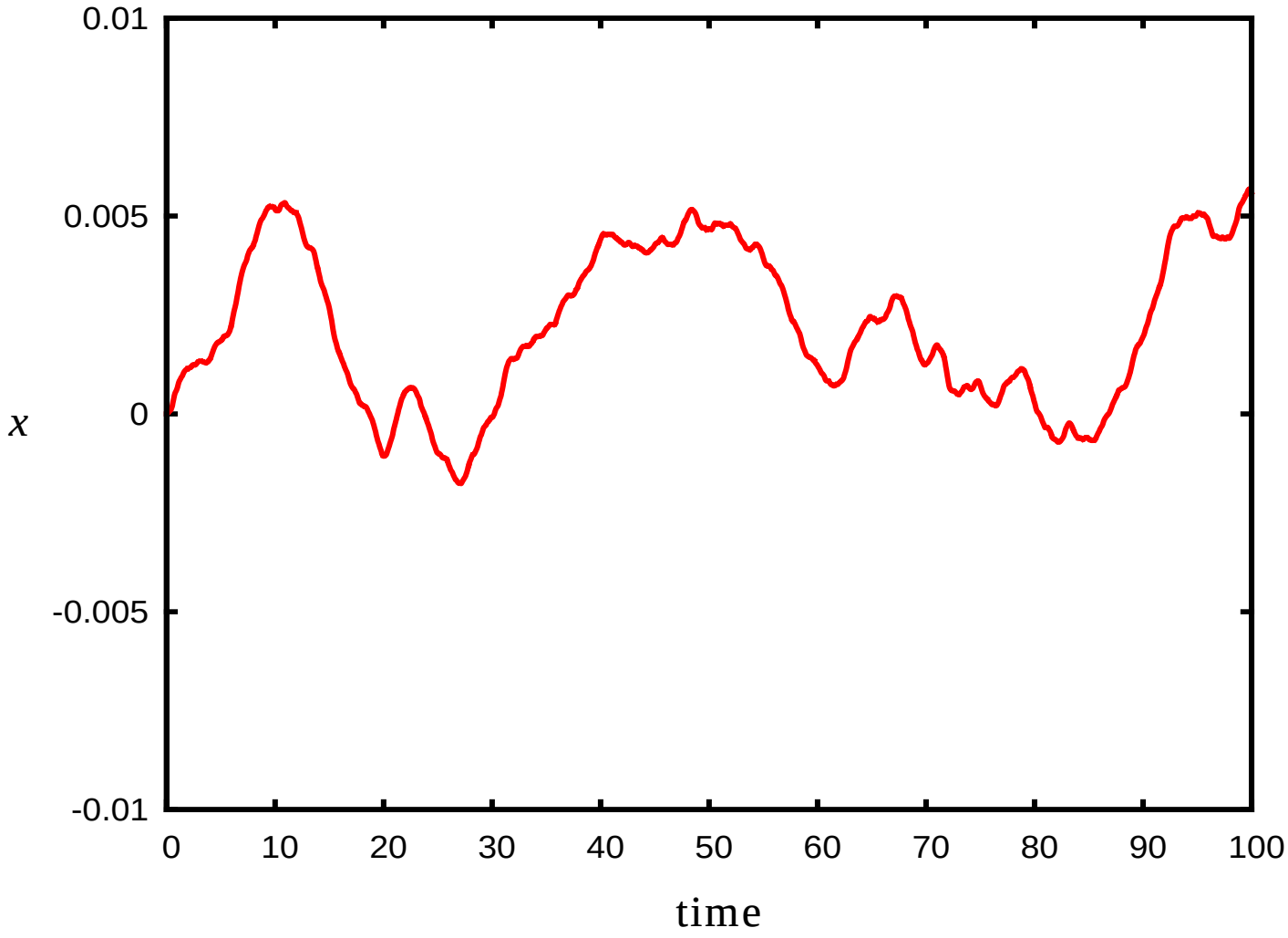
$$\left\langle \boldsymbol{\xi}(t) \right\rangle = 0$$

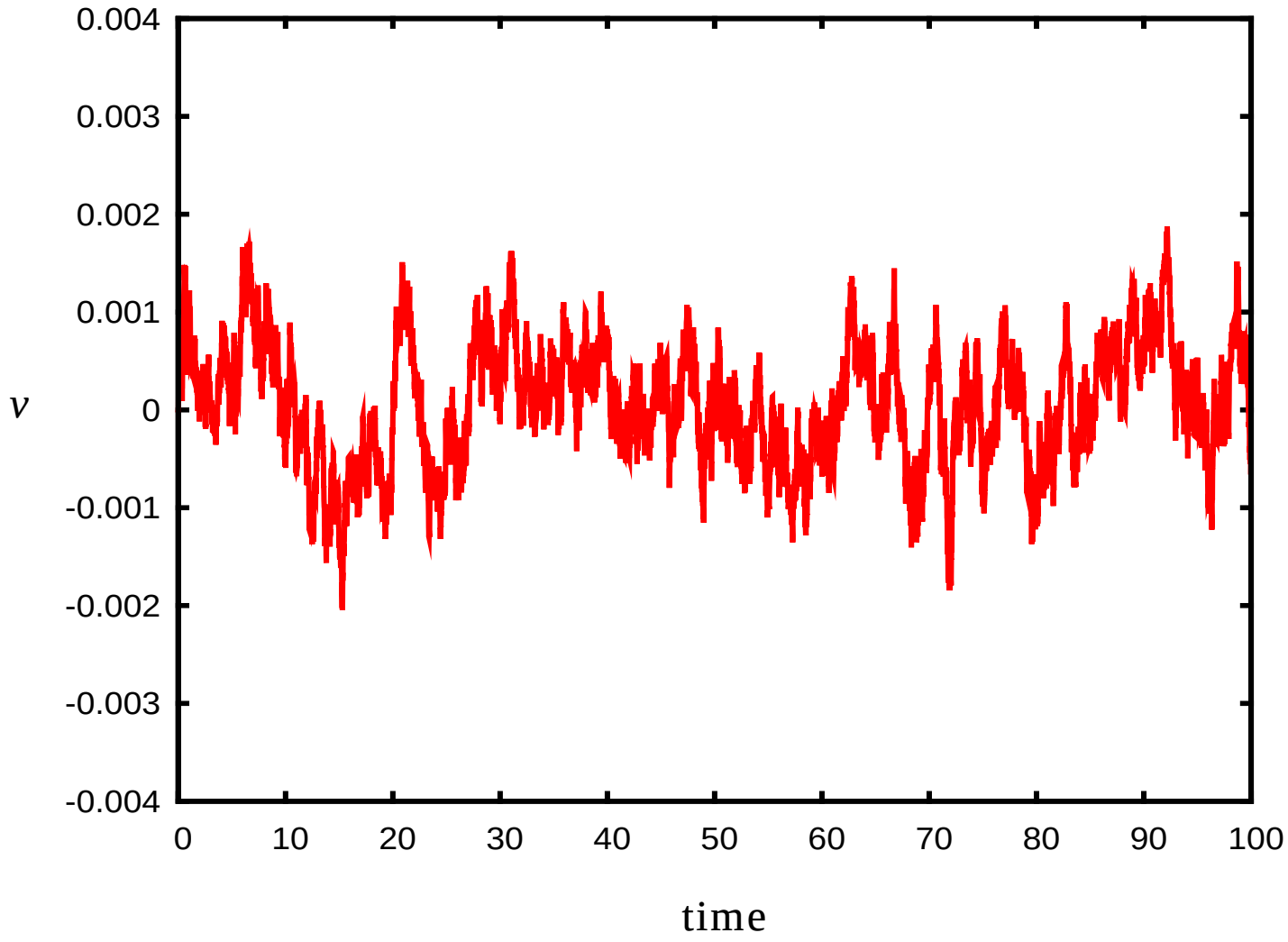
$$\left\langle \boldsymbol{\xi}(t) \cdot \boldsymbol{\xi}(s) \right\rangle = 2M\delta\left(t-s\right)$$

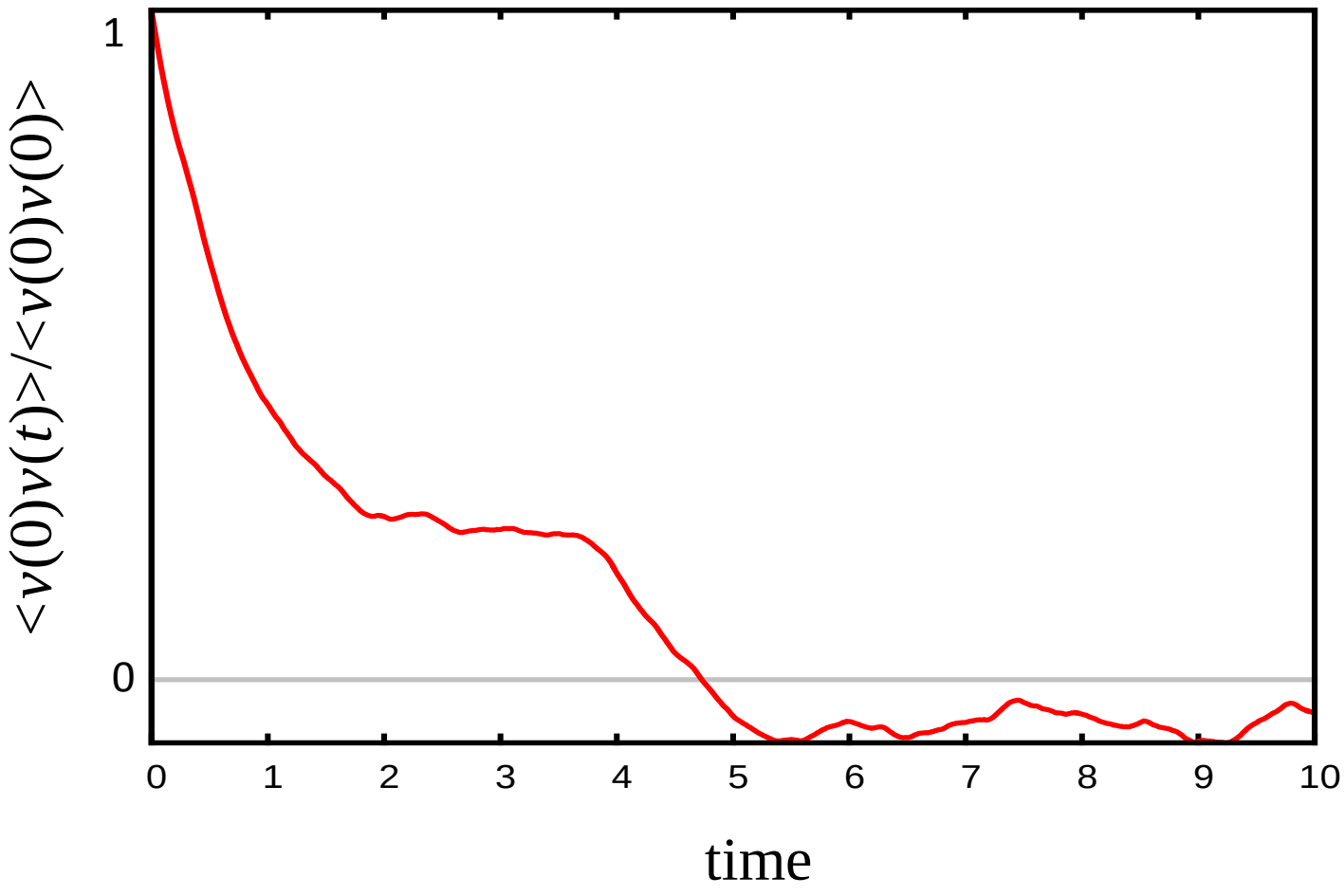
1次元系でのLangevin方程式による挙動



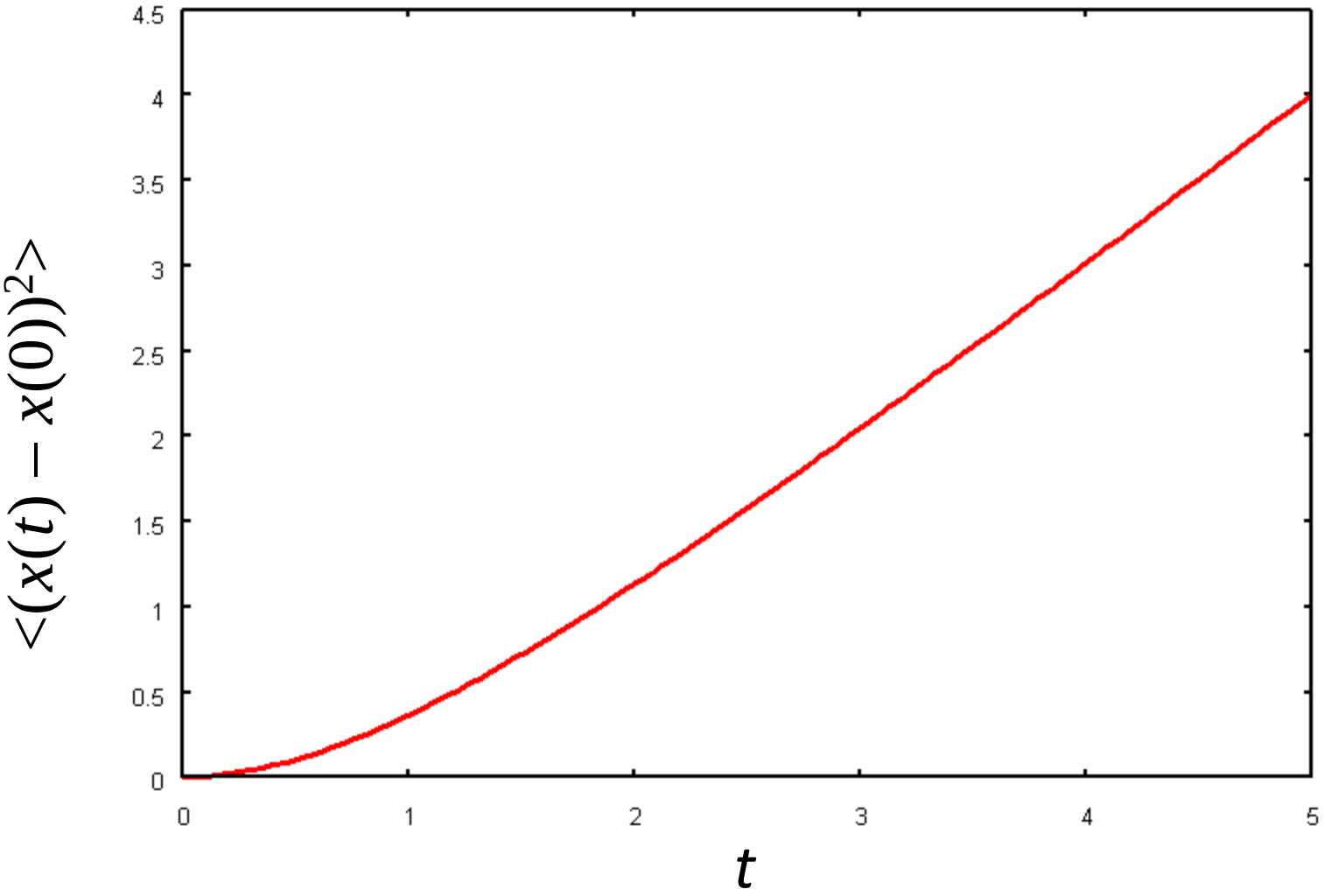
x


0.01
0.005
0
-0.005
-0.01
x
0
10
20
30
40
50
60
70
80
90
100
time


0.004
0.003
0.002
0.001
0
-0.001
-0.002
-0.003
-0.004
v
0
10
20
30
40
50
60
70
80
90
100
time

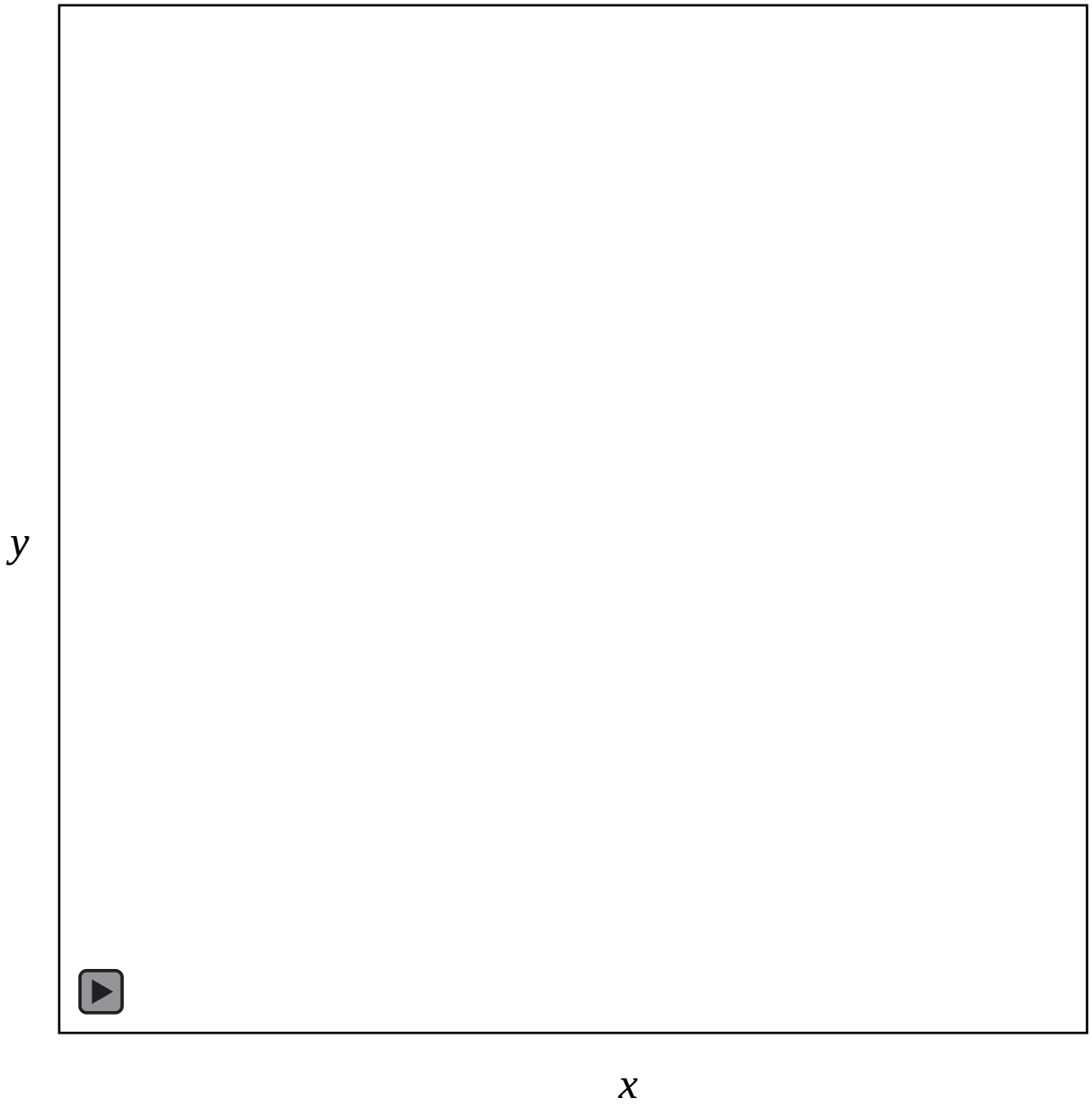


$$\langle v(0)v(t)\rangle/\langle v(0)v(0)\rangle \propto \exp(-t/\tau)$$



$$<(x(t) - x(0))^2> = (2Mt/\gamma)\,[t - (m/\gamma)\exp(-\gamma t/m)]$$

2次元での数値計算



軌跡を残すと