Supplementary Materials

The interpretation of the derivative $-\partial R(t\,|\,x)/\partial t$ as the probability density of the local accumulation time can be supported by analogy with an irreversible $A \to B$ reaction. Let $N_A(t)$ and $N_B(t)$ be the numbers of molecules A and B in volume V at time t, respectively, $N_A(t)+N_B(t)=N_0$, where N_0 is the total number of molecules in the system. At $t=0$, all molecules are in state A, $N_A(0)=N_0$, $N_B(0)=0$. As $t\to\infty$, all molecules transfer to state B, $N_B(\infty)=N_0$, $N_A(\infty)=0$. In this case the relaxation function $R(t)$ is the fraction of molecules A that survive for time t

$$R(t)=N_A(t)/N_0=1-N_B(t)/N_0\,. \tag{S.1}$$

Introducing the concentration of molecules B, $C_B(t)=N_B(t)/V$, we can write $R(t)$ in the form similar to Eq. (1) from the main text,

$$R(t)=1-C_B(t)/C_B(\infty)\,. \tag{S.2}$$

The fraction of molecules A that are converted to molecules B between t and $t+\Delta t$ is

$$R(t)-R(t+\Delta t)=\frac{N_A(t)-N_A(t+\Delta t)}{N_0}=\frac{N_B(t+\Delta t)-N_B(t)}{N_0}\,. \tag{S.3}$$

From this it follows that the lifetime probability density of molecules A, $\varphi(t)$, is given by

$$\varphi(t)=-\frac{dR(t)}{dt}=-\frac{1}{N_0}\frac{dN_A(t)}{dt}=\frac{1}{N_0}\frac{dN_B(t)}{dt}. \tag{S.4}$$

According to Eqs. (S.3) and (S.4), this function is also the probability density for the birth of a B molecule at time t.