The rate coefficient $r(t)$ for barrier crossing is approximated by the transition state result

$$r(t) = \frac{D}{\int_{\text{well}} \exp\left(-\beta \tilde{G}_{\text{NE}}(x,t)\right) \mathrm{d}x \int_{\ddagger} \exp\left(\beta \tilde{G}_{\text{NE}}(x,t)\right) \mathrm{d}x} \quad , \tag{S1}$$

where the one-dimensional free energy landscape $\tilde{G}_{\text{NE}}(x,t)$ as a function of the reaction coordinate x is obtained from projecting the two-dimensional (non-equilibrium) free energy landscape $G_{\text{NE}}(x,y,t)$ onto the reaction coordinate x (note that $\mathbf{x} = (x,y)$),

$$\tilde{G}_{\text{NE}}(x,t) = -k_B T \ln \left(\int_{-\infty}^{\infty} G_{\text{NE}}(x,y,t) \mathrm{d}y \right) \quad , \tag{S2}$$

and the latter is defined via the solution $p(x,y,t)$ of the Smoluchowski equation given by Eq. (7) on page 2 in the main text,

$$G_{\text{NE}}(x,y,t) = -k_B T \ln p(x,y,t) \quad . \tag{S3}$$

In Eq. (S1), the first integral is taken over the half-plane $x < x_b$ (well), and the second over an appropriate transition state region (‡), e.g., $x_b - \Delta x < x < x_b$ with Δx chosen such that $p(x_b - \Delta x, y, t) \ll p(x,y,t)$.

To evaluate the integrals in Eq. (S1) and in Eq. (S2), the factorization $p(x,y,t) = p_x(x,t) p_y(x,y,t)$ is used, with

$$p_x(x,t) = \frac{1}{\sqrt{2\pi}\,\sigma_x(t)} \exp\left[-\frac{(x - \langle x(t) \rangle)^2}{2\sigma_x^2(t)} \right] \quad , \tag{S4}$$

and

$$p_y(x,y,t) = \frac{1}{\sqrt{2\pi}\,\sigma_y(t)} \exp\left\{ -\frac{1}{2\sigma_y^2(t)} \left[y - \langle y(t) \rangle + C\left(x - \langle x(t) \rangle \right) \right]^2 \right\} \quad , \tag{S5}$$

where

$$\sigma_x(t) = \sqrt{e_{1x}^2 \sigma_1(t)^2 + e_{2x}^2 \sigma_2(t)^2} \quad , \tag{S6}$$

$$\sigma_y(t) = \left[\left(\frac{e_{1y}}{\sigma_1(t)} \right)^2 + \left(\frac{e_{2y}}{\sigma_2(t)} \right)^2 \right]^{-\frac{1}{2}} \quad , \tag{S7}$$

$$C = \left[\frac{e_{1x} e_{1y}}{\sigma_1(t)^2} + \frac{e_{2x} e_{2y}}{\sigma_2(t)^2} \right] \Big/ \left[\left(\frac{e_{1y}}{\sigma_1(t)} \right)^2 + \left(\frac{e_{2y}}{\sigma_2(t)} \right)^2 \right] \quad , \tag{S8}$$

and

$$\sigma_i = \sqrt{\frac{1 - e^{-2\beta\lambda_i D t}}{\beta\lambda_i}} \quad . \tag{S9}$$

is the width of $p(x,y,t)$ along the eigenvectors $\mathbf{e}_i$ of $\mathbf{C}$, with $\mathbf{C}$, $\mathbf{e}_i$, and λ_i are as defined in the main text.

The integral in y-direction in Eq. (S2) is constant and thus cancels in Eq. (S1) such that, except for normalization of $p_x(x,t)$, $\tilde{G}_{\text{NE}}(x,t) = -k_B T \ln p_x(x,t)$. Because, further, also the normalization of $p_x(x,t)$ cancels in Eq. (S1), one obtains for the rate coefficient

$$\frac{D}{r(t)} = \int_{-\infty}^{x_b} \frac{1}{\sqrt{2\pi}\sigma_x(t)} \exp\left[-\frac{(x - \langle x(t) \rangle)^2}{2\sigma_x^2(t)} \right] \mathrm{d}x \cdot \int_{\langle x(t) \rangle}^{x_b} \sqrt{2\pi}\sigma_x(t) \exp\left[+\frac{(x - \langle x(t) \rangle)^2}{2\sigma_x^2(t)} \right] \mathrm{d}x \,. \tag{S10}$$

Here, $\Delta x = x_b - \langle x(t) \rangle$ was chosen.

As the integrand of the second integral is peaked at $x = x_b$, a Taylor expansion of the exponent $(x - \langle x(t) \rangle)^2 / (2\sigma_x^2(t))$ about $x = x_b$ provides a good approximation, yielding

$$\frac{D}{r(t)} = \frac{1}{2} \left[1 + \operatorname{erf}\left(\frac{x_b - \langle x(t) \rangle}{\sqrt{2}\sigma_x(t)} \right) \right] \cdot \frac{\sqrt{2\pi}\sigma_x^3(t)}{x_b - \langle x(t) \rangle} \exp\left[\frac{(x_b - \langle x(t) \rangle)^2}{2\sigma_x^2(t)} \right] \cdot \left\{ 1 - \exp\left[-\frac{(x_b - \langle x(t) \rangle)^2}{\sigma_x^2(t)} \right] \right\} \,. \tag{S11}$$

By defining $\tau = (x_b - \langle x(t) \rangle)/(2\sigma_x^2(t))$, the rate coefficient is given by

$$r(t) = \frac{2D\tau e^{-\tau^2}}{\sqrt{\pi}\sigma_x^2(t)(1 + \operatorname{erf}(\tau))(1 + e^{-2\tau^2})} \quad . \tag{S12}$$