Supplementary Information: Transient pauses of the bacterial flagellar motor at low load

AL Nord$^{1,2}$
$^1$Department of Physics, University of Oxford, Parks Road, Oxford OX1 3PJ, UK
$^2$Single molecule biophysics dept, Centre de Biochimie Structurale, CNRS UMR 5048 UM INSERM U 1054, 29 Rue de Navacelles, 34090 Montpellier, France
E-mail: ashley.nord@cbs.cnrs.fr

F Pedaci$^2$
$^2$Single molecule biophysics dept, Centre de Biochimie Structurale, CNRS UMR 5048 UM INSERM U 1054, 29 Rue de Navacelles, 34090 Montpellier, France
E-mail: francesco.pedaci@cbs.cnrs.fr

RM Berry$^1$
$^1$Department of Physics, University of Oxford, Parks Road, Oxford OX1 3PJ, UK
E-mail: richard.berry@physics.ox.ac.uk
1. Supplementary Information

Figure 1. Simulated data. (a) Two simulated traces are shown, one from a simulated spinning Poisson stepper with pauses inserted periodically, and the other one permanently paused. Both traces have the same noise spectrum as the experimental trace shown in figure 1(d) of the main text, and the spinning trace has the same median speed of this trace. Eight pauses have been inserted into the spinning trace at locations marked by the arrows; black and white arrows show pauses which were detected and missed by the algorithm, respectively. The duration of the pauses are listed in (c). Insets show 10 ms surrounding the pauses. According to the parameter settings given in Materials and Methods, the window over which slopes were calculated was 0.89 ms, and the cutoff frequency of the high-pass filter which produced the noise of this trace was 3380 Hz. (b) The black line shows a histogram of slopes for the simulated spinning trace in (a). Green and red shading denotes slopes determined to be spinning and stalled, respectively. The red dotted line is the histogram of slopes for the paused trace in (a). (c) A table listing the pauses which were inserted into the simulated spinning trace of (a) and their detected duration.
Figure 2. Distribution of pauses. Five representative traces are shown for both WT (top row) and chimera (bottom row) motors. The green bars are a normalized histogram of the motor angle from 0 to 360°. The red dotted lines mark the angular positions of the start of each pause. The first plot is the trace from figure 1 of the manuscript. The angular position of the pauses appears uniformly distributed and do not correspond with regions of low speed, where an obstacle or surface interaction could exist, suggesting that pauses are not an artifact of particular surface interactions.

Figure 3. Normalized histograms of simulated dwell times of the motor and experimental motor pauses. The simulated dwell times come from 34 simulated traces (where dwell time is defined as the time between mechanical steps, a composite of three Poisson processes, see Materials and Methods), where the simulated traces had the same median speeds as the experimental traces. The experimental pauses are the same as shown in figure 2(a) of the manuscript. These distributions suggest that the pauses measured in this study are not simply long tails of exponentially distributed dwell times of a Poisson stepping motor, but instead a separate phenomenon. However, we note that one model of the BFM predicts a stretched exponential distribution of dwell times [28]; depending on the degree of stretch, it is conceivable that the pauses measured in this study are the tail of such a distribution. Details of the simulations are provided in Materials and Methods.
Figure 4. Periodicity of pauses in the BFM. (a) Cumulative pairwise distribution function (PDF) of all the identified pauses from WT and Na\textsuperscript{+} chimera motors in blue and magenta, respectively. A normalized PDF was generated for each individual pause of each individual motor, and all of the PDFs were summed. (b) The power spectral density of (a). Neither the cumulative pairwise distribution nor the power spectral density of the angular position of pauses show a discernible periodicity. (c) Examples of pauses (top, shown in red) and the corresponding PDF of the pause (bottom). About 90% of the pauses in both the WT and Na\textsuperscript{+} chimera motors resemble the first two examples, showing no periodicity. However, about 10% of the pauses include one or more steps in motor position during the pause, as demonstrated by the last four examples. The first peak in the PDF is roughly consistent with a rotor periodicity of 26.