lengthscale $\lambda = (\sqrt{2}/3)R_1$.

C. A dragged chucker

For passive systems, such as colloidal particles, the fluctuation-dissipation theorem (FDT) states that the mobility coefficient Γ is fundamentally related to the diffusion constant D by $\Gamma = D/k_BT$. For active systems, there is no reason why the FDT should hold. Deviations from the FDT not only serve to demonstrate that the system is out of equilibrium, but can also yield insight into the underlying physics.

To investigate the relationship between mobility and diffusion for the colloidal chucker, we carried out MC simulations in which a chucker (with $R_1/R_2 = 10$) is dragged in a fixed direction by a constant force F (for example, using optical tweezers). We measure the velocity v of the chucker in the direction of the force. The mobility coefficient Γ is defined by $v = \Gamma F$; this can be compared with the value of D_{eff} obtained in Figure 5. In this work, we use values of F which approximately correspond to the magnitude of the gravitational force on a bacterium.

Figure 10 shows the steady state chucker velocity v, as a function of the chucking rate, expressed as the dimensionless ratio $k_c R_2^2/D_1$, for two different values of the pulling force F. This velocity depends strongly and nonmonotonically on the chucking rate, in a markedly different way to the effective diffusion constant of Figure 5.

Combining the results of Figures 5 and 10, we obtain Figure 11, which describes how the ratio $\Gamma k_B T/D_{\text{eff}}$ depends on $k_c R_2^2/D_1$. Deviation of $\Gamma k_B T/D_{\text{eff}}$ from unity (green dashed line) corresponds to violation of the FDT. We observe firstly that deviations from FDT in this system are strong (up to a factor of 3) and nonmonotonic. Depending on the chucking rate and the pulling force, mobility may dominate diffusion, or vice versa. As might be expected, the deviations from FDT are stronger for the larger pulling force. While it is not surprising that the FDT does not hold in this nonequilibrium system, what is perhaps unexpected is that the relationship between the mobility and diffusion constants has such a complex dependence on both the chucking rate and the applied force for this rather simple model.

The trends observed in Figure 11 can be tentatively related to changes in the solute configuration around the chucker, for different chucking rates and pulling forces. Naively, one