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Log-Normal Distribution of Single Molecule Fluorescence Bursts in Micro/Nano-Fluidic Channels

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The width and shape of photon burst histograms pose significant limitations to the identification of single molecules in micro/nano-fluidic channels, and the nature of these histograms is not fully understood. To reach a deeper understanding, we performed computer simulations based on a Gaussian beam intensity profile with various fluidic channel diameters and assuming (i) a deterministic (noise-free) case, (ii) photon emission/absorption noise, and (iii) photon noise with diffusion. Photon noise in narrow channels yields a Gaussian burst distribution while additional strong diffusion produces skewed histograms. We use the fluctuating residence time picture [Phys. Rev. Lett. 80, 2386-2388 (1998)] and conclude that the skewness of the photon number distribution is caused by the longitudinal diffusive component of the motion of the molecules as they traverse the laser beam. In the case of strong diffusion in narrow channels, this effect leads to a log-normal distribution. We show that the same effect can transform the separate peaks of the photon burst histograms of multiple molecule mixtures into a single log-normal shape.

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