ACHIEVING MAXIMUM POSSIBLE EFFICIENCY OF ARBITRARY ORIENTED SINGLE MOLECULE IMAGING

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Many single molecule (SM) quantum systems absorb and emit light as dipole oscillators. Because of emission pattern anisotropy and dependence of molecule emission rate on the mutual orientation of the molecule transition dipole moment and excitation light field vector, conventional fluorescent microscopy techniques don’t provide observing arbitrary oriented SMs. So, we have a problem of arbitrary oriented SM imaging. Possible solution of the problem is using cylindrical vector beams (CVBs) in laser-scanning confocal fluorescence SM (LSCFSM) microscopy. LSCFSM imaging efficiency parameter we use is $\varepsilon = \frac{\text{max}_{x,y}(I_{\text{min.ex}})}{\text{max}_{x,y}(I_{\text{max.ex}})}$ [1]. Here max$_{x,y}$ is intensity maximum on a SM image ($x$, $y$ are image plane coordinates); $I_{\text{min.ex}}$ ($I_{\text{max.ex}}$) – the intensity of the image of minimally (maximally) excited SM. We have demonstrated in [1] the possibility of highly efficient visualization of arbitrary oriented SMs in homogeneous media by using elliptically polarized CVBs ($\varepsilon=96\%$).

It was shown in [2] that one can collect 99% of emission of an arbitrary oriented SM placing it to a special microcavity. Noteworthy, this microcavity doesn’t affect SM fluorescent properties. So, the authors suggested an advanced technique for collection of an arbitrary oriented SM emission, but they didn’t attempt to excite arbitrary oriented SMs. In the present work we (1) calculate LSCFSM images of molecules placed to the microcavity suggested in [2], (2) find the $\varepsilon$-parameter maximum by varying ellipticity parameters of the CVB from [1] and removing the beam central part, who’s diameter is varied as well. We have found maximal $\varepsilon$-parameter value $\varepsilon=94\%$. Fig. 1 displays calculated LSCFSM images of differently oriented SMs. The angles $\theta_d$ and $\phi_d$ assign SM orientation. The dipole ($40^0,0^0$) is minimally excited, whereas two others are maximally excited. There is no obvious difference between three images intensity maximums. Thus, we can observe arbitrary oriented SMs collecting all their emission and determine their orientations by analyzing image intensity distribution.

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