Ultrafast and Ultrasensitive Detection and Imaging of Single Cardiac Troponin-T Molecules and SARS-CoV-2 Viral Particles

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The detection and visualization of individual atoms and molecules have always been one of the priority tasks of both fundamental scientific and practical importance: the study of the effects of quantum electrodynamics, the development of monatomic/single-molecular devices, visualization of biological tissues, and many others. Recently, single-molecule detection methods have found application for detecting ultra-low concentrations of substances: analyte molecules are sequentially detected in a sample one by one, known as the single-molecule counting method (SMCM). In our study, we consider SMCM in sensorics based on the use of: (i) fluorescence of molecules, (ii) strong optical coupling. Both approaches show sensitivity at the level of single molecules, allowing for 5-minutes-per-detection of practically important biomarkers of human diseases. As a practical implementation of the SMCM, we show: (i) detection of the ultra-low concentration of Troponin biomolecules in human blood - the most important biomarker of human cardiovascular diseases, at a level of 10–20 fM, (ii) detection of SARS-COV-2 viral particles (human coronavirus). The fundamental limitations of the sensitivity of such approaches and the issues of their practical implementation will be considered.