NUMERICALLY EXACT DYNAMICS OF FUNCTIONAL QUANTUM SYSTEMS - APPLICATIONS TO GaAs QUANTUM DOT QUBITS AND 2-DIMENSIONAL SPECTRA OF VERY LARGE PHOTOSYNTHEITC COMPLEXES

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Functional quantum systems is an emerging research field which includes quantum engineering (the design of technologies that make use of quantum mechanics to outperform their classical counterparts, such as quantum computers, quantum communication devices, quantum thermometers, quantum telescopes, etc.) and the study of natural processes where quantum mechanics provides some improvement that cannot be realized with classical mechanics (possible examples are photosynthesis, animal navigation, the sense of smell, etc.). Being able to predict how a quantum mechanical system changes (ie, how its density matrix changes), given its hamiltonian, is paramount in quantum engineering as one needs to know which hamiltonian will give the desired outcome. Likewise, being able to predict density matrix dynamics in natural systems can help in understanding the system's mechanism, in controlling the system's processes, and can be helpful if designing a technology which attempts to mimic a natural process. State of the art techniques for calculating density matrix dynamics of functional quantum systems in real-time, and with numerically exact accuracy, have been developed over the last year. These techniques will be presented, followed by applications for quantum dot based quantum computing, and for calculating the 2D spectra of large biological systems.