Advancing quantum transport for nuclear reactions

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We report progress on developing quantum transport theory for central nuclear reactions, based on nonequilibrium Green's functions. The challenge in advancing that theory is in handling the enormous amount of information within the Green's functions that are matrices in the pairs of space and time arguments. In the semiclassical limit, one finds that those arguments represent the momentum and energy content of a system at a given position and time. Simple estimates show that blind attempts to discretize the Green's function arguments are going to overwhelm computer capabilities in the foreseeable future. A more peripheral issue before the theory is that of preparation of the initial state in a manner that is consistent with the approach for the collisions. With the goal of tackling the above issues, we investigate a system of slabs colliding in one dimension within the mean-field approximation. While this system poses no computational obstacles of any kind, it allows to test strategies for realistic reaction simulations. With regard to the initial state, we find that we can prepare a state consistent with the collision evolution by adiabatically converting the hamiltonian, from one for which we know the solutions, to the interacting one. Regarding the matrix structure, we find that only elements next to the diagonal in the spatial representation matter in practice for reaction evolution. When we artificially remove elements away from the diagonal in the matrix description of a reaction, we find from nearly no effect to very little onto the progress of a reaction, depending how aggressively we suppress the elements. The insensitivity to the far-away elements can be associated with the late-term expansion of the reacting system, that causes any structures within the matrix arguments to move away from the diagonal of the matrix but hardly ever back to the diagonal. Dropping of the far-away elements amounts to a momentum-space coarse-graining of the functions within their Wigner representation. The findings bode well for the possibility of carrying out realistic reaction simulations, particularly in that the information that needs to be followed in those simulations can be tamed.