Unphysical and Physical Solutions in Many-Body Theories: from Weak to Strong Correlation

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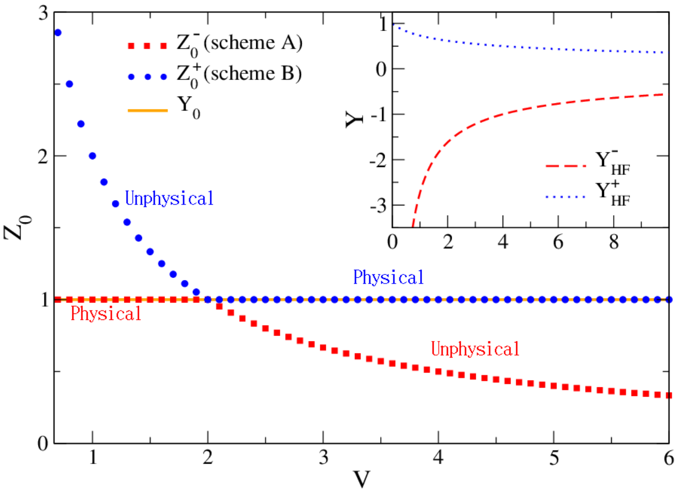

The noninteracting Green's function Z_0 as a function of the interaction V obtained in a simple one-point model using two different iteration schemes (**A** and **B**). Squares (red): Z_0^-, the solution of scheme **A**; circles (blue): Z_0^+, the solution of scheme **B**; continuous line (orange): Y_0, the physical noninteracting Green's function

Many-body theory is largely based on self-consistent equations that are constructed in terms of the physical quantity of interest itself, for example the density or the one-body Green's function. Therefore, the calculation of important properties such as total energies or photoemission spectra requires the solution of non-linear equations that have unphysical and physical solutions [1,2]. In this work we show using a simple model in which circumstances one runs into an unphysical solution (see the figure for an example), we illustrate the dramatic consequence that many-body theories become unpredictive, and we indicate how one can overcome this problem [3]. Our findings point out that currently used strategies to develop approximations are only valid in a regime of weak to moderate interaction strength, and that they have to be completely changed in the strong-correlation regime. We propose a new strategy for strong correlation.

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[2] J. A. Berger, P. Romaniello, F. Tandetzky, B. S. Mendoza, C. Brouder, and L. Reining, New J. Phys. 16, 113025 (2014)
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