Kadanoff-Baym Equations for open quantum systems

Tim Neidig, Jan Rais, Hendrik van Hees, Marcus Bleicher, and Carsten Greiner

ITP Goethe Uni, Max von Laue Strasse 1, Frankfurt am Main, Germany

We study the temporal evolution of quantum mechanical fermionic particles exhibiting one bound state within a one-dimensional attractive square-well potential in a heat bath of bosonic particles. For this open quantum system we formulate the non-equilibrium Kadanoff-Baym equations for the system particles by taking the interactions to be elastic 2-2 scatterings with the heat-bath particles. The corresponding spatially imhomogeneous integro-differential equations for the one-particle Greens's function are solved numerically. We demonstrate how the system particles equilibrate and thermalize with the heat bath and how the off-diagonal elements of the density matrix, expressed in the one-particle energy eigenbasis, decohere, so that only the diagonal entries, i.e. the occupation numbers, survive. In addition, the time evolution of the (retarded) Green's function also determines the spectral properties of the various one-particle quantum states.

European Union's Horizon 2020 research and innovation program under grant agreement No 824093 (STRONG-2020) Helmholtz Forschungsakademie Hessen für FAIR (HFHF) Deutsche Forschungsgemeinschaft (DFG) CRC-TR 211 "Strong-interaction matter under extreme conditions"

[1] A. Caldeira and A. Leggett, Physica A: Statistical Mechanics and its Applications 121, 587 (1983)

[2] G. Lindblad, Communications in Mathematical Physics 48, 119 (1976)

[3] C. W. Gardiner and P. Zoller, Quantum Noise, 2nd ed., edited by H. Haken (Springer, 2000)

[4] L. Kadanoff and G. Baym, Quantum Statistical Mechanics (1961)

[5] J. Schwinger, J. Math. Phys. 2, 407 (1961)

[6] L. V. Keldysh, Zh. Eksp. Teor. Fiz. 47, 1515 (1964)

[7] P. Danielewicz, Annals Phys. 152, 239 (1984)

[8] N. E. Dahlen, R. van Leeuwen, and A. Stan, J. Phys.: Conf. Ser. 35, 340 (2006)

[9] N. E. Dahlen and R. van Leeuwen, (2007), arXiv:cond-mat/0703411

[10] A. Stan, N. E. Dahlen, and R. van Leeuwen, J. Chem. Phys. 130, 224101 (2009)

[11] P. Danielewicz, Annals of Physics 152, 305 (1984)

[12] H. S. Kohler, N. H. Kwong, and H. A. Yousif, Comp. Phys. Comm. 123, 123 (1999)

[13] K. Balzer, S. Bauch, and M. Bonitz, Phys. Rev. A 82, 033427 (2010)

[14] G. Baym and L. P. Kadanoff, Phys. Rev. 124, 287 (1961)

[15] G. Baym, Phys. Rev. 127, 1391 (1962)

[16] T. Neidig, K. Gallmeister, C. Greiner, M. Bleicher, and V. Vovchenko, Phys. Lett. B 827, 136891 (2022)