REVIEW

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Review

A review of modeling interacting transient phenomena with non-equilibrium Green functions

Mark R Hirsbrunner[1,4], Timothy M Philip[2,4], Bora Basa[1], Youngseok Kim[2], Moon Jip Park[1] and Matthew J Gilbert[2,3]

[1] Department of Physics, University of Illinois at Urbana-Champaign, Urbana, IL 61801, United States of America
[2] Department of Electrical and Computer Engineering, University of Illinois at Urbana-Champaign, Urbana, IL 61801, United States of America
[3] Department of Electrical Engineering, Stanford University, Stanford, CA 94305, United States of America

E-mail: matthewg@illinois.edu

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Abstract

As experimental probes have matured to observe ultrafast transient and high frequency responses of materials and devices, so to have the theoretical methods to numerically and analytically simulate time- and frequency-resolved transport. In this review article, we discuss recent progress in the development of the time-dependent and frequency-dependent non-equilibrium Green function (NEGF) technique. We begin with an overview of the theoretical underpinnings of the underlying Kadanoff–Baym equations and derive the fundamental NEGF equations in the time and frequency domains. We discuss how these methods have been applied to a variety of condensed matter systems such as molecular electronics, nanoscale transistors, and superconductors. In addition, we survey the application of NEGF in fields beyond condensed matter, where it has been used to study thermalization in ultra-cold atoms and to understand leptogenesis in the early universe. Throughout, we pay special attention to the challenges of incorporating contacts and interactions, as the NEGF method is uniquely capable of accounting for such features.

Keywords: non-equilibrium Green functions (NEGF), time-dependent transport, frequency-dependent transport, quantum transport

(Some figures may appear in colour only in the online journal)

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[4] These authors contributed equally.

