Preface

About the Thesis

This thesis presents a study of a few periodically driven quantum systems from the Floquet theory perspectives. The periodically driven systems are studied for the past many decades. However, these systems have recently renewed interest among scientists due to their applications in realizing new phases of matter. Depending on the desired phase of matter, one first selects a static system with some intrinsic properties and then manipulates those properties by a properly designed driving protocol. The Floquet theory gives a theoretical framework to derive the effective desired Hamiltonian from an initial static Hamiltonian driven by a properly designed periodic field. However, for most physical cases, it is not possible to obtain the effective Hamiltonian exactly by any analytical means under the Floquet theory. However, this theory gives the flexibility to employ some perturbation theories to derive effective Hamiltonian. In literature, two extreme cases are considered for the perturbative derivations: low frequency and high frequency driving. This thesis focusses on the latter one and applied two perturbation schemes: Van Vleck and Brillouin-Wigner. This thesis has focussed on three systems: (1) Double kicked top, (2) Kicked hard core bosons, and (3) Coupled kicked top. The system (1) is interesting because its classical dynamics is chaotic, but the quantum spectrum shows nice fractal. This study explores the self-similar properties of the spectrum. The study further finds that this spectrum shares some common “number theoretical" features with the celebrated Hofstadter butterfly. The study of the system (2) is interesting because this is one of the special systems whose effective Hamiltonian can be derived exactly. This study compares the dynamical features of this system under a single and a double kicked driving. The former driving protocol shows a dynamical localization; however, the later form of the driving can give various dynamics, which include full and partial dynamical localization and also a complete absence of any localization. Finally, the system (3) is studied because this is another kind of special system that is nonintegrable for its driven as well as effective static Hamiltonian versions. This study reveals that this system has some of the nonstandard symmetry properties proposed recently.

To the Reader

Broad field of research for this thesis is theoretical condensed matter physics. Interested persons in this area probably survey the topic covered in this thesis conveniently. Complete derivations for all the relations mentioned in the core chapters of thesis are given in appendices to make thesis as self-sufficient as possible.

Thesis Outline

This thesis has six chapters and four appendices. The first chapter is the introductory one. The second one is about the mathematical formalism. Then, Chapters 3-5 present different results of the thesis. The conclusion is drawn in Chapter 6. Summary of the thesis organization is as follows:

- **Chapter** 1 discusses the motivation behind this thesis and highlights the importance of periodically driven systems by reviewing some important research works carried out in this area.

- **Chapter** 2 discusses the mathematical formalism used throughout the thesis. Mainly focusses on the Floquet theory and its application in designing different perturbation theories to derive the effective static Hamiltonian of the periodically driven system.

- **Chapter** 3 focuses on a *double kicked top system* whose spectrum shows nice fractal behavior. Using the Floquet theory, the effective Hamiltonian of this system is calculated using the perturbation theory. The spectrum of this Hamiltonian is similar to the quasienergy spectrum of the driven system. Importantly, this study finds that this spectrum and the spectrum of the celebrated Hofstadter butterfly spectrum shares self-similarity features.

- **Chapter** 4 discusses the results of a 1D hard core bosonic system on the lattice under the presence of δ-function kick driving with an onsite staggered potential. Two different δ-kicked protocols are considered: single and double kicks. For the first protocol, the system shows dynamical localization. For the latter case, the system shows various features, which include partial and complete dynamical localization, and the absence of any localization.

- **Chapter** 5 discusses the calculation of the effective time independent Hamiltonian for a coupled kicked top system. Classical dynamics of the effective Hamiltonian shows chaos in some parameter regime. Its quantum mechanical counterpart has both standard and nonstandard symmetries.

- **Chapter** 6 concludes the research carried out in this thesis and spread some light on the future scopes.

- Some rigorous derivations are presented in *four* appendices.

  - **Appendix** A presents a detailed derivation of the Van Vleck and Brillouin-Wigner perturbation based method for the derivation of the effective time independent Hamiltonian.

  - **Appendix** B discusses a complete derivation of the general formula for the Floquet Hamiltonian or effective Hamiltonian of the periodically driven systems using the Van Vleck expansion method. This appendix also discusses the Farey sequence.

- **Appendix** C has many essential calculations related to the hard core bosonic system.
- **Appendix** D gives a general prescription to calculate the effective Hamiltonian for the periodically driven system using the Brillouin-Wigner method.