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Physics 542 - Quantum Optics
Project Proposal

Project Title: **The Application of Floquet Theory in Quantum Optics**

Abstract: When solving the two-level system problem, RWA is widely used, but the RWA is valid only when the Rabi frequency is much smaller than the transition frequency. When RWA cannot be used, a common treatment is to apply the Floquet theory, in which case the evolution of the system is expressed in a Fourier series in terms of the oscillation frequency. In this project, we will introduce the Floquet theory, the temporal analog of Bloch theory, and apply it to solve two-level system problems. Then we will have a closer look at the solutions by solving the system numerically. Lastly, we will look at the application of this approach in solving research-level problems, such as quantum optimal control and time crystals.

Outline:

1. The Floquet theory and the Bloch theory
2. The Floquet Hamiltonian and the Floquet modes
3. Application to the two-level system
4. Numerically solving the Floquet problem
5. Transition Probabilities from Floquet theory
6. Floquet engineering with optical lattices
7. Time Crystals
8. Quantum Optimal Control

Some references (to be added):

1. K. Viebahn, *Introduction to Floquet theory* (Boulder School for Condensed Matter and Materials Physics).
2. F Campaioli, J. H. Cole, and H. Hapuarachchi. A Tutorial on Quantum Master Equations. arXiv:2303.16449 [quant-ph] (2023).
3. D. V. Else, D. Bauer, and D. Nayak. Floquet time crystals. *Phys. Rev. Lett.*, 117:090402 (2016).
4. A. Castro, A. De Giovannini, S. A. Sato, H. Hubener, and A. Rubio. Floquet engineering the band structure of materials with optimal control theory. *Phys. Rev. Research*, 4:033213 (2022).