

Rabi Oscillations in ^{87}Rb and ^{85}Rb gas

Physics 480
(Dated: Spring 2020)

I. PERSPECTIVE AND OBJECTIVE

This experiment aims to measure the frequency of Rabi oscillations, a physical quantity of great significance for the case of a quantum two-level system perturbed by resonance radiation. What physical systems may be modeled as two-level quantum system? Is it system of broad importance? We are beginning to find out. It may seem odd to attempt the experiment using Rb isotopes rather than with hydrogen covalently bonded to a molecule in the liquid state, not the least because Rb has a hyperfine structure split into multiple sub-levels by the Zeeman effect because of the externally imposed magnetic field common in optical pumping experiments. It is not a two level system, our Rb atom. Or is it? Could it be something very close to a two level system if it were subject to optical pumping? It is the point of these experiments to find out. Some sample data is shown in Fig. 1. The point of the paper then will be to model the Rabi oscillations created with the optical pumping apparatus. Specifically, how does the quantum mechanics of two level systems ‘model’

1. the *frequency* of the Rabi oscillations, and
2. the *decay* of the Rabi oscillations?

An important part of each paper is context. Aspects of what this means can be found in the introduction of a very important paper¹ on rotating coordinate systems used to understand nuclear magnetic resonance experiments. Evolved and more sophisticated experiments are served by this model, experiments that did not exist at the time when this theoretical framework was first worked out and applied in a concrete case. The model is important and casts, not a long shadow, but a bright search light into the present and future darkness, allowing us to see things we’d otherwise miss. Quoting Rabi et al., ” This need is sufficiently great that several authors have had to include a partial description of the rotating coordinate method *in order to describe their experi-*

ments effectively[my italics]”. Also, find, read, and cite important papers that help you do this (explain your experiment effectively) as well as papers that make those sweeping claims about the applications and import of the fundamental physics.

II. PRE-TUTORIAL AND PRE-LAB READINGS

1. TEXT² Ch 7.3.4 while not directly about Optical pumping, this brief discussion of Rabi oscillations to this experiment.
2. The Optical Pumping manual³. This time focus on theory section 2-G and experiment section 4-D.

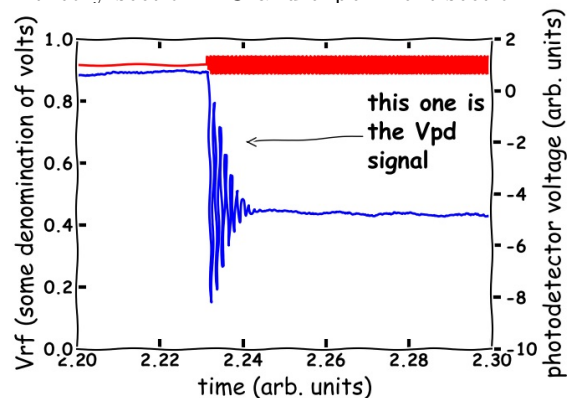


FIG. 1. This plot of detector signal vs. time

3. F. D. Colegrove, L. D. Scheerer, and G. K. Walters, *Polarization of ^3He gas by Optical Pumping*, Phys. Rev. **132**, 2561 (1963).

III. PROCEDURE

We will do the experiments described 4-D. There are two primary results to obtain for each isotope as outlined above.

¹ I.I. Rabi, N.F. Ramsey, and J. Schwinger, ‘Use of Rotating Coordinates in Magnetic Resonance Problems’, Phys. Rev. **26** 167 (1954).

² A.C. Melissinos Jim Napolitano, *Experiments in Modern Physics*, 2nd. Ed., Elsevier Science (USA), 2003; see Chapter 6, sections 1-4.

³ See our BB course site, folder ”Some Manuals and Guides”.