The Case Against Linear Response Theory: CHM676 Extra Credit

Due 12/6/2019

1 Introduction

Our treatment of molecular spectroscopy depends heavily on the *response theory* framework in which spectroscopic response is written as a perturbative expansion in increasing powers of the electromagnetic field. Although response theory has proven to be an extremely powerful tool in understanding physical systems, it is not without its detractors. One of the best known is Nico Van Kampen, whose name also featured prominently in John Bell's discussion of the measurement problem. Your assignment is to read Van Kampen's concentrated argument *against linear response theory* [*Physica Norvegica.* Vol. 5, Nos. 3-4, 1971] and evaluate its validity.

2 Instructions

Your answers should be e-mailed to my Purdue address in a single, PDF-format file, either typed or *legibly* hand-written and scanned. Use the subject line "CHM676 Extra Credit: Against Measurement". Use the file name "`<lastname>_against_linear_response.pdf`". Answers to each question should consist of 1 - 5 cohesive and grammatically complete sentences. Credit will be assigned primarily based on a demonstrated effort to think carefully about the problem, not on technical proficiency. The assignment is worth 2 of the 10 available extra credit points for the course (2% of a letter grade.)

3 Questions

1. Van Kampen begins his case by noting that macroscopic physics "abounds with phenomena in which some external force or agency acts on a system and provokes a response." In the context of molecular spectroscopy, what is the "external force or agency" that induces spectroscopic response?
2. What is the "fatal flaw" to which Van Kampen objects in linear response theory? How is this illustrated by his "Galton board" example in Section 5?
3. What is a *stosszahlansatz*?
4. Van Kampen argues that linear response theory only works because the randomness needed to stabilize the response is provided "at the initial instant" and remains operative forever after due to the assumed linearity of the dynamics. Do the results of this recent paper [Kryvohuz and Cao, *Phys. Rev. Lett.* 96, 030403 (2006)] support this view?
5. One weakness in Van Kampen's argument is that he switches between quantum and classical viewpoints as though they are equivalent – without demonstrating that this is actually the case. Based on the results in [*J. Chem. Phys.* 122, 024109 (2005)], explain why quantum mechanics might naturally provide exactly the *stosszahlansatz* that Van Kampen maintained was necessary for a stable response theory.

You can find some of my own thoughts on Van Kampen's analysis in [*J. Chem. Phys.* 148, 064101 (2018)].