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Research Proposal: What is ψ?

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A Proposal to Research on What is ψ

Introduction

Since the early 1900s, quantum mechanics has been an exceptional successful theory due to its authentic empirical predictions. The era of quantum theory dated the years of 1906 to 1926, this epoch constituted the most protracted revolutionary period in modern physics. The first discoveries in quantum mechanics was from M Planck's with the Quantum theory (1900), Einstein on the light Quantum theory (1905), Bohr with the Hydrogen atom (1913), Quantum statistics by N Bose's (1924), Heisenberg on matrix mechanics (1925) as well as the wave mechanics by E Schrodinger (1926). The scientific revolution of quantum theory from the 20^{th} centuries comprised of the statistical interpretations of quantum mechanics which introduced the probability concept as an inherent feature of the fundamental physical laws.

In 1928, M Born was the first to discover that the square of the Schrodinger wave equations (energy densities of space) could be used to predict the probability of where the particle would be found at a defined position of space. To understand the philosophy behind this discovery, Born's rule which has been precisely tested in several experiments is applied to associate the wavefunction with the probability of a measurement on the system. This rule states that a projective measurement of an observable on a system governed by a wavefunction $I\psi>$ aimlessly obtain the eigenvalues of an observable and the probability of obtaining an eigenvalue (q_i) is mathematically expressed as $I<q_i I\psi>I^2$. The Born's interpretation of statistical quantum theory was indeed the pillar of quantum mechanics, this led this interpretation as one of the axioms of quantum mechanics.

In this document I propose a review on how Born's discovery came about, the review will discuss the quantum theory principles behind his interpretation of the modulus of the wavefunction $I\psi I^2$ as the probability density of locating a particle at different positions of space. The discussion is as well extended to statistical interpretation of quantum mechanics other than the Orthodox view.

Aims and Objectives

I propose to review the available literature on what explicitly is the wavefunction ψ as derived in the Schrodinger wave equations as well as how Born proposed the idea of the absolute square of these wave equations to be used empirically to predict the probabilities of finding a particle at defined positions of space. In this review, I will achieve the following goals:

1. Expound in detail what is the wavefunction (ψ) in particular and what it physically describes in quantum physics.

2. Investigate on how Born's proposal of the modulus of the wavefunction as the probability density came about.
3. Explicitly discuss the statistical interpretations of quantum mechanics other than the just the Orthodox position.

Literature review

This section presents my plan for achieving the aims discussed on the previous part. Since the early 1920, Born proposal has led him in building one of the axioms in quantum mechanics. There has arisen strong interest in the derivation and understanding of the physics Born used precisely. As a consequence of interest, there has been several publications of books and articles on this subject. As a matter of fact, I have obtained several articles and relevant books on this subject from the library as well as the online resources. The sources I have gathered should provide sufficient information I need to write my review. The following paragraphs discuss the ways I will use these sources into my research.

The first goal of my research project is to explicitly explain what is meant by the wavefunction (ψ) in quantum theory and how physically could be described. The viewpoint of this relies on discussing the ψ-epistemic view and the ψ-ontic view as well as how precisely these viewpoints led to conclusions made that introduced the quantum mechanics and its applications in various aspects of quantum theory.

The second goal of my research is to investigate on how Born's interpretation of the modulus of the wavefunction (ψ) as the probability density came about. This involves deriving and discussing arguments made by Born in supporting his assumption, that will include discussion on Born's remarks on probability and causality which led him to conclusions with Heisenberg derivation of the uncertainty relation and Bohr's formulation of complementarity, this might also allow me to discuss in details the mathematical formalism he used in his "Quantum mechanics of collision phenomena" which he also made conclusions to his statistical interpretation of the wavefunction (ψ).

In achieving these two goals, I will rely mainly on few articles and books that give a detailed overview to statistical interpretations as well as the introduction quantum mechanics, relevant books includes Introduction to Quantum mechanics and an article on Max Born Statistical interpretation of Quantum mechanics.

The third primary goal of the literature review is based on the philosophical and mathematical formalism, the discussion is based on the statistical interpretation of quantum mechanics other than just the Orthodox position, this will involves the analysis on the analogy of orthodoxy which relies on assumptions of projection postulate and the eigenvalue-eigenvector link that is not incorporate with the practical application of quantum mechanics, the collapse of the wavefunction(this will includes indirect evidence, inadequacy

of repeated measurement etc), the lab view of quantum mechanics in practice and its limitations and lastly the decoherent views of quantum mechanics in practice.

Work Plan

This section presents my work schedule for performing the research project. The research will come to an end in a scientific formal report that will be completed by September 2018 along with an oral presentation to be done in the following month after the completion of the final report. In reaching this goal I intent to follow the schedule presented in a table below. I have already gathered enough resources to start drafting this project, therefore I will spend most of the time gathering and evaluating through the sources for relevant information.

Key Action Steps	Timeline	Expected Outcome
Goal: 1		
Gathering of additional sources	30 April - 21 May	I expect to have obtained more sources and studied them, I will spend most time gathering the resources.
Goal: 2		
Evaluation of the sources: • What is ψ? • Born's interpretation of $I\psi I^2$ • Statistical interpretation of quantum mechanics	28 May - 16 July	I expect to have extracted and noted down enough information I need for the research.
Goal: 3		
Illustrations for preparing the first draft	18 July – 25 July	Enhance the understanding of the proposed points, organise some ideas and write them with references. This will also include creating an outline for the first draft.
Goal: 4		
Drafting the final report	28 July - 6 August	Report draft should take a week since I would have

		prepared in the previous week, therefore I expect to be submitting the first draft on the 8th.
Goal: 5		
Revising (Editing) of the final report	13 August - 18 August	I will edit my draft of the final report, this will include the review by my tutor as well as my supervisor. I expect to have finished with the edit by the 18th.
Goal: 6		
Binding of the final report	20 August – 7 September	Binding the report up will mean connecting all the revised or edited part of the research project into one final report. I expect to be submitting the final report on the 10th.
Goal: 7		
Oral presentation preparations	8 October – 25 October	In this two weeks I will be preparing the presentation of the research project which is scheduled between the 26 to 27, I expect to be done with the preparations by the 25th.

References

[1] Statistical Interpretation of Quantum Mechanics, Max Born Science, New Series, Vol.122, No.3172 (Oct 14, 1955), pp.675-679 http://www.jsatr.org/Stable/pdf/1752079.pdf

[2] Max Born's Statistical Interpretations of Quantum Mechanics, A Pais Science (17 Dec 1982): Vol.218, Issue 4578, pp.1193-1198 DOI: 10.1126/Science.218/4578/1193

[3] Introduction to Quantum Mechanics (David J Griffith, Cambridge University Press, 2016)

[4] Meaning of the Wave Function (The ontology of quantum mechanics), Shan Gao (7 Nov 2016): arXiv:1611.02738v1 [quanta-ph.]

[5] What is orthodox quantum mechanics? David Wallace (20 April 2016) : http://philsci-archive.pitt.edu/12050/1/orthodoxy.pdf