Regensburger Nachtgespräche

Quantum Mechanics
Frequently Asked Questions

Lorenz G. Lechner

Universität Regensburg

5 Juli 2005

What is quantum mechanics?

"Quantum mechanics is the description of the behavior of matter and light in all its details and, in particular, of the happening on an atomic scale."

Richard P. Feynman

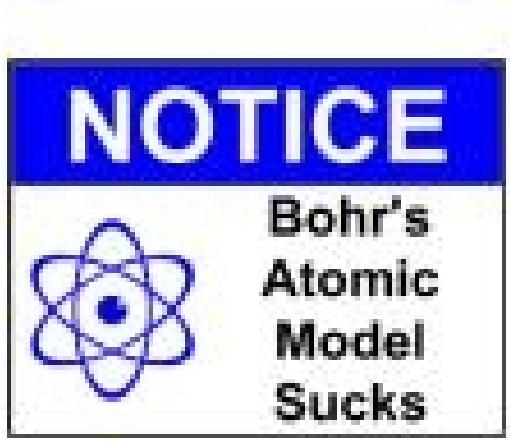
Why do we need it?

Why do we need it?

There are several questions classical mechanics is not able to answer:

- Why are atoms stable?
- How does blackbody radiation work?
- Is light an particle or a wave?
- etc.

More general: Classical mechanic fails on the atomic scale.

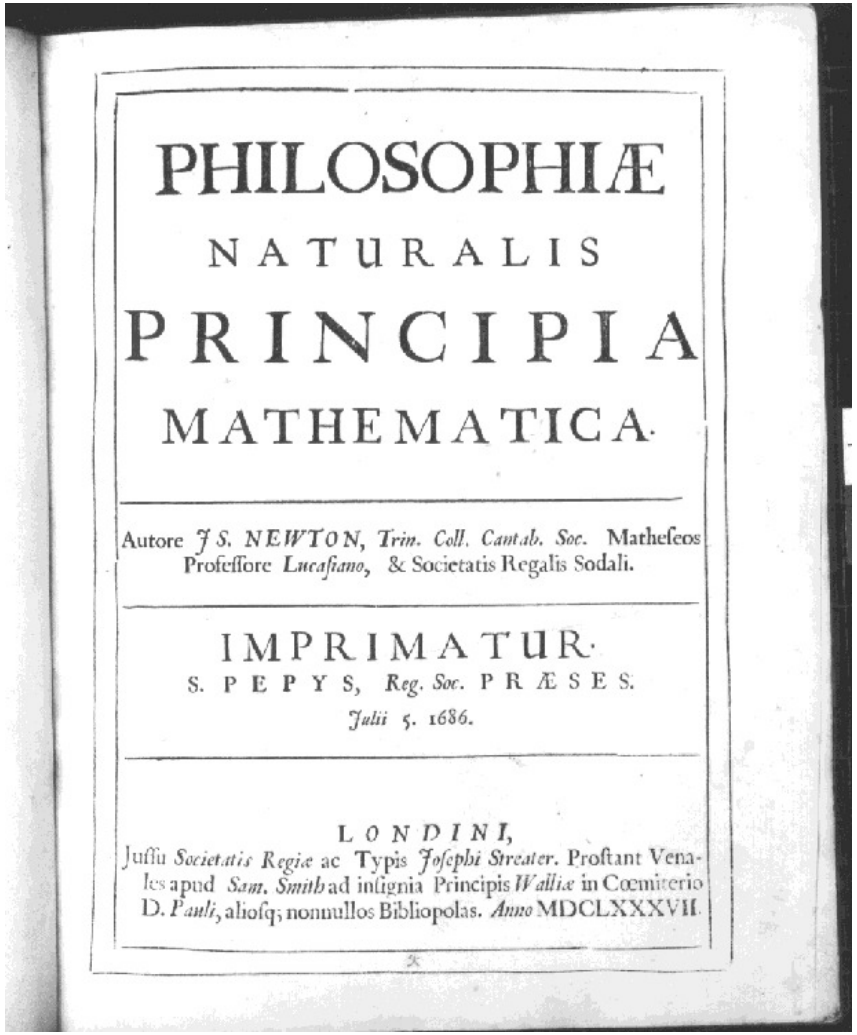


Is classical mechanics now wrong?

Is classical mechanics now wrong?

- Quantum mechanics is more fundamental then classical mechanics
- The theory of QM is in perfect agreement with experimental results
- However, for macroscopic problems the calculus of QM is to difficult

Thus, QM is an extension to classical mechanics which is still valid for every day problems.



PHILOSOPHIÆ
NATURALIS
PRINCIPIA
MATHEMATICA.

Autore *J S. NEWTON, Trin. Coll. Cantab. Soc.* Matheseos Professore *Lucasiano,* & Societatis Regalis Sodali.

IMPRIMATUR.
S. PEPYS, *Reg. Soc.* PRÆSES.
Julii 5. 1686.

LONDINI,
Jussu *Societatis Regiæ* ac Typis *Josephi Streater.* Prostant Venales apud *Sam. Smith* ad insignia Principis *Walliæ* in Cœmiterio D. *Pauli,* aliosq; nonnullos Bibliopolas. *Anno* MDCLXXXVII.

What does QM tell us?

What does QM tell us?

The Time Dependent Schrödinger Equation

We may write

$$-\frac{\hbar}{i}\frac{\partial\Psi(t)}{\partial t} = \mathcal{H}\Psi(t)$$

where

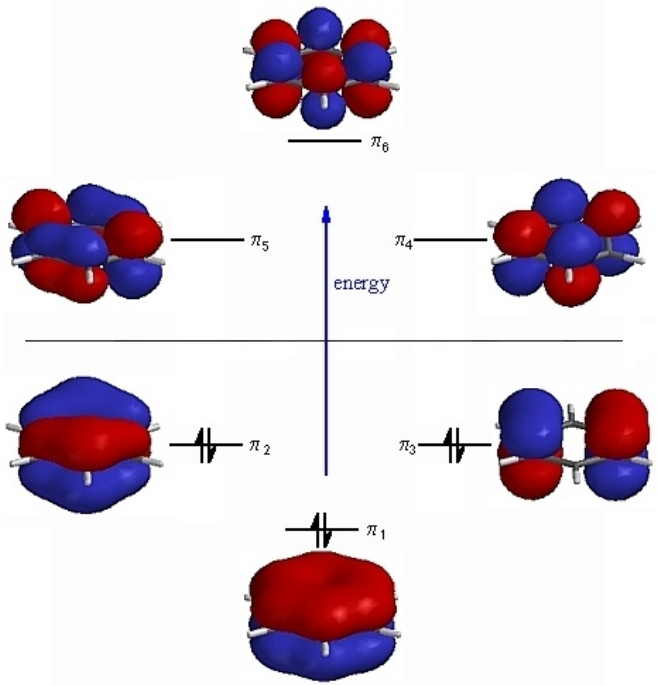
$$\mathcal{H} = \sum_I \frac{1}{2m_i}\left(p_i - \frac{e_i}{c}\mathcal{A}\right)^2 + V(r) = \mathcal{H}_{molecule} + \mathcal{H}_{radiation} + \mathcal{H}_{int}$$

with

$$\mathcal{H}_{molecule} = \mathcal{H}_o = \sum_i \left(\frac{p_i^2}{2m_i} + V(r)\right); \quad \mathcal{H}_o|n\rangle = E_n^{(o)}|n\rangle$$

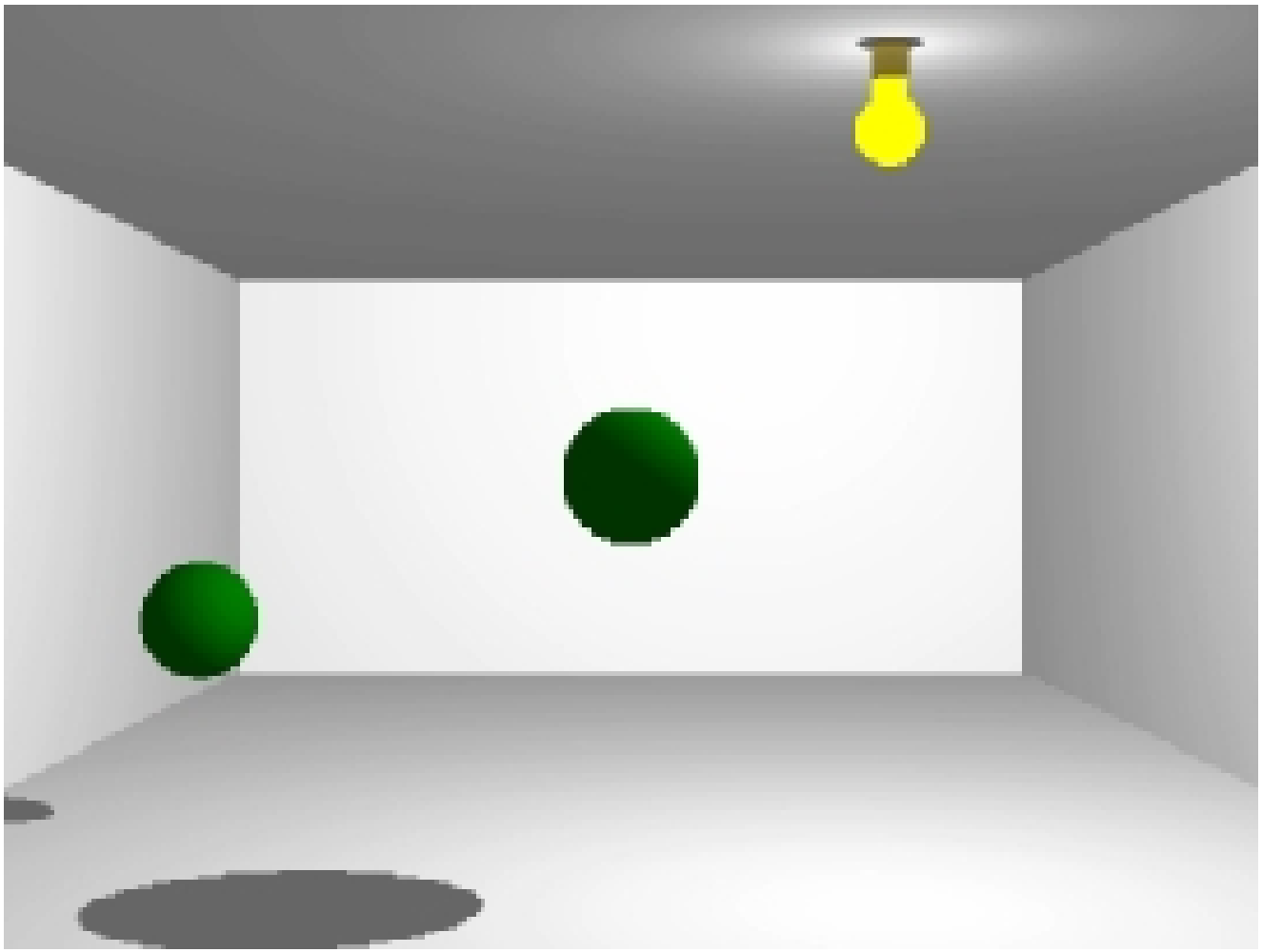
$$\mathcal{H}_{rad} = \sum_s \frac{\omega_s}{2}(a_s a_s^+ + a_s^+ a_s); \quad \mathcal{H}_{rad}|N_s\rangle = \sum_s (N_s + \tfrac{1}{2})\hbar\omega_s|N_s\rangle$$

$$\mathcal{H}_{int} = \mathcal{H}_{int}^{(1)} + \mathcal{H}_{int}^{(2)}$$



What is the Heisenberg Uncertainty Principle?

What is the Heisenberg Uncertainty Principle?



What is the Heisenberg Uncertainty Principle?

or more descriptive

What is the Heisenberg Uncertainty Principle?

What is Schrödinger's cat?

What is Schrödinger's cat?

- Radioactive decay triggers mechanism that kills the cat
- Atoms are in a superposition of the states "decayed" and "not decayed"
- Thus, the cat has also is in a superposition of "dead" and "alive"
- As long as the box is closed, the cat is neither dead nor alive

However

- This contradicts our experience that a cat has to be in either one of the states

For Further Reading

- **The Feynman Lectures on Physics**, Vol. 3
  by Richard P. Feynman
- **Die Kopenhagener Deutung der Quantentheorie**
  by Werner Heisenberg and Niels Bohr
- **Quantum Mechanics**
  by E. M. Lifshitz and L. D. Landau

For Further Reading

- **The Feynman Lectures on Physics**, Vol. 3
  by Richard P. Feynman
- **Die Kopenhagener Deutung der Quantentheorie**
  by Werner Heisenberg and Niels Bohr
- **Quantum Mechanics**
  by E. M. Lifshitz and L. D. Landau

Enjoy the talk!

There is no "there" there
Gertrude Stein and Quantum Physics

Jan D. Kucharzewski

Introduction

- Heuristic approach to Gertrude Stein's literary modernism
- Attempt to establish isomorphic correspondences between Stein's writings and Quantum Physics
- Deploying the "Wave-Particle-Duality" as a metaphor for certain distinctive characteristics of Stein's texts

Disclaimer

- ***I AM NOT A PHYSICIST!***
- “Reduction” of Quantum Mechanics to a conceptual analogy, focusing on its epistemological and ontological implications.
- I am not going to prove that Stein knew anything about Quantum Physics!

Gertrude Stein (1874 – 1946)

- One of the most radical and most prolific modernist writers
- Continuously searching for new modes of artistic expression
- Abandonment of narrative structures
- Emphasis on the persistent now-ness of being ("continuous present")
- Deceptively simple, almost 'monochromatic' vocabulary
- Repetition/Insistence as means of linguistically capturing the stream of thought
- Often mistaken for a Dadaist.

- He certainly very clearly expressed something. Some said that he did not clearly express anything. Some were certain that he expressed something very clearly and some of such said that he would have been a greater one if he had not been one so clearly expressing what he was expressing. Some said he was not clearly expressing what he was expressing and some of such of them said that the greatness of struggling which was not clear expression made of him one being a completely great one.

  - Gertrude Stein, “Matisse” (1932)

A red stamp

If lilies are lily white if they exhaust noise and distance and even dust, if they dusty will dirt a surface that has no extreme grace, if they do this and it is not necessary it is not at all necessary if they do this they need a catalogue.

- Gertrude Stein, *Tender Buttons* (1914)

Gertrude Stein/Quantum Physics

- It is not possible to establish a direct, causal connection between Gertrude Stein and Quantum Physics.
- Large amounts of her work chronologically precede the publication of the most significant breakthroughs in this field.
- Stein: “I cannot explain this too often any one is of one’s period.”

William James (1842 – 1910)

- Older brother of Henry James
- Studied medicine, philosophy, and biology
- Pragmatist philosopher
- Major work: *The Principles of Psychology* (1890)

The Stream of Thought

- “Consciousness, then, does not appear to itself chopped up in bits. Such words as ‘chain’ or ‘train’ do not describe it fitly as it presents itself in the first instance. It is nothing joined; it flows. A ‘river’ or a ‘stream’ are the metaphors by which it is most naturally described. In talking of hereafter, let us call it the stream of thought, of consciousness, or of subjective life.”

Convergence I: William James/Niels Bohr

- Gerald Holton detects “remarkable analogies and similarities between the ideas of Bohr and James.”
- Bohr: “William James is wonderful in the way he makes it clear […] that if you have some things… they are so connected that if you try to separate them from each other, it just has nothing to do with the actual situation. […] We should really get into this.” (Interview, November 17, 1962)

Contexts of Perception

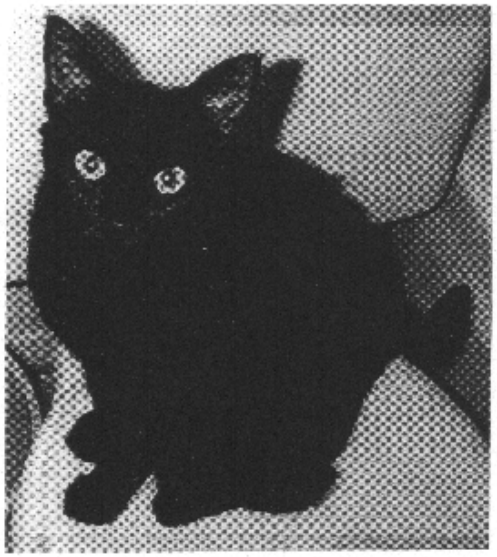
- James: “Every perception is an acquired perception.” Our “mental reaction to every given thing is really a resultant of our experience in the whole world up to that date,” and “we see things in a new light [from one year to another].” (*The Principles of Psychology*).
- Bohr: For “objective description and harmonious comprehension it is necessary in almost every field of knowledge to pay attention to the circumstances under which evidence is obtained” (“Quantum Postulate”).

- “Pas de lieu Rhône que nous.”
- “Paddle your own canoe.”
- Bohr: The principle of complementarity "implies the impossibility of any sharp separation between the behaviour of atomic objects and the interaction with the measuring instruments which serve to define the conditions under which the phenomena appear."
- James: “Whilst part of what we perceive comes through our senses from the object before us, another part (and it may be the larger part) always comes out of our own head.”

Complementarity

- Bohr: “I hope, however, that the idea of complementarity is suited to characterize the situation, which bears a deep-going analogy to the general difficulty in the formation of human ideas, inherent in the distinction between subject and object.”
- James: “Like a bird’s life, [consciousness] seems to be made of an alternation of flights and perchings. […] Let us call the resting places the ‘substantive parts,’ and the places of flight the ‘transitive parts,’ of the stream of thought. It is very difficult, introspectively, to see the transitive parts for what they really are. If they are but flights to conclusion, stopping them to look at them before the conclusion is reached is really annihilating them.”

Wanted:
$10,000 Reward



Schrödinger's Cat
Dead and Alive

Convergence II: James/Stein

- Stein studied under James during her years at the Harvard Annex from 1893 to 1897.
- James: Language “works against our perception of truth. […] We name our thoughts simply, each after its thing, as if each knew its own thing and nothing else. What each really knows is clearly the thing it is named for, with dimly perhaps a thousand other things. It ought to be named after all of them, but never is.”
- Stein: A “noun is a name for anything, why after a thing is named write about it.”
- Stein: “Nothing could bother me more than the way a thing goes dead once it has been said.”

Insistence

- James: “When the identical fact recurs, we must think of it in a fresh manner, see it under a somewhat different angle, apprehend it in different relations from those in which it last appeared. And the thought by which we cognize it is the thought of it-in-those-relations, a thought suffused with the consciousness of all that dim context.”
- Stein: “I am inclined to believe that there is no such thing as repetition,” for “once started […] expressing anything there can be no repetition because the essence of that expression is insistence, and if you insist you must each time use emphasis and if you use emphasis it is not possible while anybody is alive that they should use exactly the same emphasis.”

Phonetic Particles in James/Stein

- James: “This is probably the reason why, if we look at an isolated printed word and repeat it long enough, it ends by assuming an entirely unnatural aspect. Let the reader try this with any word on this page. He will soon begin to wonder if it can possibly be the word he has been using all his life with that meaning. It stares at him from the paper like a glass eye, with no speculation in it. Its body is indeed there, but its soul fled. It is reduced, by this new way of attending to it, to its sensational nudity.”
- Stein: “Rose is a rose is a rose is a rose is a rose…..”

Tentative Hypothesis

- Transitive parts = energy/wave-qualities
- Substantive parts = particle-qualities
- Meaning = energy/waves
- Sounds/Signs = bodies/particles

Three Lives (1909)

- Contrapuntal composition: the same attributes repeatedly appear in connection to a certain character.
- The more we learn about the character, the less appropriate the attributes seem to become.
- While the phonetic/typographic materiality of the word remains fixed, its contextual meaning changes.

Effect

- The “insistence” on certain attributes in ever differing contexts creates a sense of motion.
- Example: the “good Anna” has an aggressive need to dominate relationships and the story gives no suggestion of character development.
- The word “good” is thus invested with new meanings. It becomes fluid.
- The ‘static’ character makes the movement of the word visible.
- The word seem to move *against* the static character.

Quantum Paradox I: *Three Lives*

- Dichotomy between Stein's emphasis on the phonetic (i.e. physical, material, and fixed) aspects of language and her concern with the "continuous present" (i.e. the constant resemantization of words and dematerialization of meanings).
- Stein's attempt to make the transitions of these semantic shifts visible through insistence stands in sharp contrast to the reduction of words to their "sensational nudity."

- Insistence underlines the dislocation of textual meanings and the importance of contexts and semantic transitions.
- The reduction of words to their “sensational nudity” decontextualizes and isolates the solidity of single linguistic units.
- Two complementary perceptions of language: the non-representational dimension of language vs. the transformation of words into pure potentials that collapse into momentary contextual meanings.
- Semantic waves vs. phonetic particles.

Quantum Paradox II: “Pictures”

- “There is the oil painting in its frame, a thing in itself. There it is and it has to look like people or objects or landscapes. Besides that is must not completely only exist in its frame. It must have its own life. And yet it may not move or imitate movement, not really, nor must it stay still. It must not only be in its frame but it must not, only, be in its frame.”

Quantum Paradox III: *Tender Buttons*

A carafe, that is a blind glass

A kind of glass and a cousin, a spectacle and nothing strange a single hurt color and an arrangement in a system to pointing. All this and not ordinary, not unordered in not resembling. The difference is spreading.

Thank you very much!