The Unconscious-Conscious-Physicist experiment. An argument in opposition to the hypothesis that consciousness collapses the wave function in quantum mechanical measurement process

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The aim of this paper is to disprove the hypothesis that consciousness is necessary in the quantum measurement process. In order to achieve this target, I propose a variation of the *Dead-Alive Physicist* and *Schrödinger's cat* thought experiments called "UCP", short for "Unconscious-Conscious Physicist". The intuition of a specific *strategy* has enabled me to plan the experiment in such a way as to logically justify the inconsistency of the above hypothesis and to oblige its supporters to rely on an alternative interpretation of quantum mechanics in which a real world of phenomena exists independently of our conscious mind and where observers play no special role. Moreover, in this case, the measurement apparatus will be complete, in the sense that the experiment, given that it includes also the experimenter, will begin and end exclusively within a sealed room. Hence, my analysis provides a logical explanation of the relationship between the observer and the objects of her/his experimental observation; this and a few other implications are discussed in the fifth section and in the conclusions.

Keywords: the measurement problem in quantum mechanics, mind-body problem, Schrödinger's Cat, Wigner's friend, observer's consciousness, wave-function collapse.

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1 Introduction

This paper describes an alternative version of the Schrodinger's cat experiment and is aimed at highlighting the inconsistency of the "idealistic" interpretation of quantum mechanics (QM).

We use the term "idealistic" to refer to the (orthodox) Copenhagen [Niels Bohr (1885-1962)] view of atomic phenomena taken to the extreme. This view is based on two essential points: 1) a quantum system is in a state of genuine indeterminacy until it is measured; 2) the act of measurement forces the quantum system to adopt one of its potential states with a probability that can be calculated by means of the wave function (WF) which is appropriate for that system and for the measurement to which it is subject.

Thus, according to the Copenhagen interpretation, an elementary quantum phenomenon is not a phenomenon until such time as it is concluded by an *irreversible* measurement process and this would require some sort of explicit specification of the boundary between quantum and non quantum mechanical systems, given that the measurement process would be conceived as a non quantum mechanical phenomenon.

Unfortunately, this interpretation does not explain when and how a measurement process takes place. This omission gives rise to the so called "measurement problem", which weakens its claim to *completeness*. Indeed, the Copenhagen interpretation is not the only possible interpretation of QM that is subject to the measurement problem which, in more general terms, may be considered as that of defining a satisfactory transition process between micro-systems characterized by quantum state uncertainty and macro-systems obeying the deterministic laws of classical physics.

From the 1930's onwards, the measurement problem has been at the centre of a scientific-philosophical debate with the purpose of establishing how (or whether) the collapse of the WF takes place [6–27]. The debate on this issue has given rise to endless discussions among physicists and, so far, there has been a lack of consensus regarding which interpretation might be correct.

Furthermore, the Copenhagen interpretation of QM gives rise to some thought-provoking demonstrations, usually called "paradoxes", such as the *Einstein–Podolsky–Rosen* (EPR) [1], *Schrödinger's Cat* [2] and *Wigner's friend* experiments, which render questionable the theory's claim to completeness, unless one assumes that consciousness plays a fundamental role in the implementation of the quantum measurement process.

Eugene P. Wigner (1902-1995), following the books published in 1932 and 1955 by the mathematician John von Neumann [3-4] (1903-1957) and a little book published in 1939 by the physicists Fritz London and Edmond Bauer [5], developed an argument in favour of the consciousness assumption, leading to the thesis of the wave-function (WF) collapse at biological-mental level, [1] here more simply called "idealistic interpretation" of QM.

Starting from the orthodox view, the *idealistic interpretation* assumes that it is the observer's consciousness the fundamental factor which is able, in some unspecified and mysterious manner (Wigner refers to "a deus ex machina" [11, p. 188]) to collapse the quantum system down into one only of its possible states. Here *consciousness* would not be playing a merely passive role in the measurement process, but would be the only factor capable of determining the transition from the ambiguous realm of potentials to the unequivocal realm of actual events. This is the kind of vision I mean when referring to the idealistic interpretation of QM.

By its very nature, the idealistic interpretation is difficult to evaluate, both in purely conceptual terms and, obviously, at the empirical-experimental level.[2]

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[1] There are two main theses arguing that consciousness and quantum mechanical measurement are connected to each other: one thesis (von Neumann, London and Bauer, Wigner, Stapp; see refs 3-5 and 22) holds that the observer's consciousness causes the collapse of the wave function, thus claiming to complete the quantum-to-classical transition, while the other thesis (Penrose; Penrose and Hameroff; see refs 18-21) aims at demonstrating the opposite, i.e. that consciousness emerges from the so called "Orchestrated Objective Reduction".

[2] Actually, neither von Neumann nor Wigner ever explained how it is possible for something of non-physical nature to produce a physical effect like the collapse of a quantum system.

The objective of the thought experiment described hereafter is to demonstrate how the idealistic interpretation of QM, also known as "consciousness causes collapse hypothesis" (CCCH) of the wave-function (WF), is forced to conclusions incompatible with the assumption that consciousness[3] is necessary for providing a complete explanation of quantum measurement process.

2 The UCP experiment

In this section I will propose an experiment, in which a male Physicist named "**P**" is inside an impenetrable room. For all intents and purposes, the room is a so-called perfectly isolated system. In a sense, **P** will play the role of Schrödinger's cat in the original experiment, but – as will be seen – he will have, in my view, a much more important role.

On the wall behind **P** (figure 1) there is an apparatus, L,[4] programmed to emit at a precise time a photon in the direction of a beam splitter, BS, inclined at 45°. Beyond the BS, along the direction of the transmitted photon, there is the detector D_T, while along the direction of the reflected photon there is the detector D_R, placed on top of a box, connected to a hammer; the hammer is connected to a Switch-On-Battery (**SOB**) that, if pushed, activates a bell (**B**).

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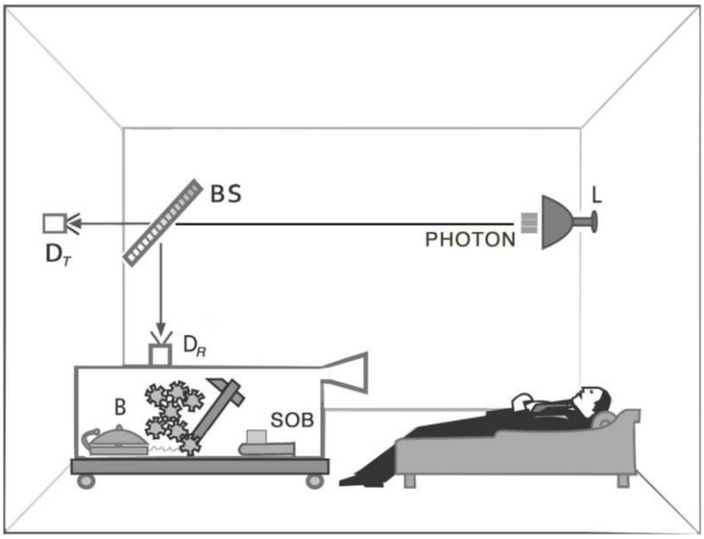

Fig. 1 The experimental room, where **P** is under the **TCB** effect from a few seconds after 1:00 PM to 2:00 PM

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The experiment is planned as follows:

1. L will emit a photon at 2.00 PM.
2. **P** has deliberately drugged himself one hour beforehand, at 1.00 PM, with a dose of a powerful narcotic, crucial for the experiment, called "**TCB**" (Temporary Consciousness Breaker) and 100% guaranteed to cut out conscious awareness for two hours and prevent the later recall of events that occurred during the time of

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[3] We don't know how consciousness works and do not have any idea of its nature. Nonetheless we are undoubtedly certain to possess it as the intimate and the most familiar of our experiences. In general, consciousness is defined as the faculty that allows a human subject to be aware of her/his self and of her/his mental activities, as well as the faculty to learn from the perception of external events to which these activities are directed. Leading contemporary scientists in the field have tried to lay the foundations for a science of consciousness, but none of them has yet been able to boast a promising theoretical approach. The Australian philosopher of the mind David J. Chalmers argues that, to open a window towards the understanding of consciousness, it would be required to solve the so called "difficult problem", consisting in finding a correlation between the functional mechanisms engendered by the neural activity of the brain and conscious experience, i.e. the phenomenon that allows the owner of that brain to feel specific effects in the first person.

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[4] In such a mechanism a battery is supplying electric power.

drug action; therefore, **P** will regain consciousness precisely at 3.00 PM; I say precisely at 3:00 PM, but I mean "precisely" when you can claim that **P** is no more under the **TCB** effect.
3. If D_T registers, **B** inactive.
4. If D_R registers, the hammer is unhooked, falls on the **SOB**, **B** activated for more than one hour.

Let us now briefly consider how the quantum theory describes the experiment: the photon is emitted from L, it collides with BS at 2:00 + Δt_1 PM (where Δt_1 is the travelling time of the photon from L to BS) and splits in two beams, one transmitted, *T*, moving along the direction of the detector D_T, and the other reflected, *R*, moving along the direction of the detector D_R, with a probability amplitude (in our example) of $1/\sqrt{2}$ for the photon to be received by each of them at 2:00 + Δt_2 PM (where Δt_2 is the travelling time of the photon WF from L to D_T and D_R, both placed at the same distance from L).

According to the Copenhagen interpretation of QM, the WF ψ is described as a linear superposition[5] of two states:

$$|\psi> = (|\text{photon } T> + |\text{photon } R>)/\sqrt{2} \qquad (1)$$

until the instant in which a measurement process takes place. This is the instant in which the WF collapses and only one of the two possible states becomes an actual outcome.[6]

If one assumes, as Wigner[9, p. 181 and p. 187], "the existence of an *influence* of consciousness on the physical world" and that "the measurement is not completed until a well-defined result enters our consciousness", that is until the WF collapses down into either one of its two component parts, then inside the room there is not one unique defined state as long as **P** is under the **TCB** effect, but rather *a linear superposition* of the two states described above which, while time is passing, is propagating along the whole macroscopic measurement system up to the scale of **P**'s brain. Subsequently, the superposition will cease to be linear when it reaches **P**'s consciousness.

Consequently, there are two possibilities or chains of events, here called $E(_{T,\ R})$, which will travel according to the superposition principle until a certain instant of the experiment:

- E_T: *T* (part of the wave function transmitted), D_T registers, precisely at 3:00 PM **P** is *conscious* of being in the silent room.
- E_R: *R* (part of the wave function reflected), D_R registers, triggers the hammer, **B** is activated, precisely at 3:00 PM **P** is *conscious* of being in the noisy room.

Thus, a *complete measurement apparatus* will be available, in the sense that this experiment, given that it includes also the experimenter, will begin and end exclusively within the sealed room.

3 Formal description of the UCP experiment

All supporters of the. CCCH may believe that any QM experiment, no matter whether applied to a cat or to a human being, must give rise, in the end, to the same conclusions drawn by Wigner from his thought friend's experiment and from his additional and stronger hypothesis [11,pp.185-196] concerning the role of consciousness in the quantum measurement process.

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[5] A superposition of states can never be observed, since the system collapses to a single state at the instant that a measurement takes place.

[6] As well known, in QM experiments, the probabilities of measuring one or the other of two alternative outcomes are effectively the same calculated through formal procedure, according to the wave-packet reduction postulate based on the Born rule (introduced by Max Born); this rule, although being one of the most mysterious principles in quantum physics, is quite simple: it states that the probability of obtaining each of the possible outcomes is equal to the square of the corresponding amplitude. In our example the WF is the set of the two amplitudes described in equation (1), hence the probability is ½ for both alternative outcomes.

In discussing the UCP experiment described in section 2, you and I will put ourselves in Wigner's place in order to verify whether or not there are the conditions for **P**'s consciousness to bring about the collapse of the WF.

To this end, the orthodox interpretation of quantum mechanics does not preclude an observer situated outside the experimental room from describing the WF ψ, in the interval of time between 2:00 + Δt_1 and 3:00 PM, as follows:

$|\psi\rangle$ = (|photon T > |D_T registers > |**B** inactive > |**P** *unconscious* > + |photon R >
|D_R registers > |the hammer falls > | **B** active > |**P** *unconscious* >) /√2 (2)

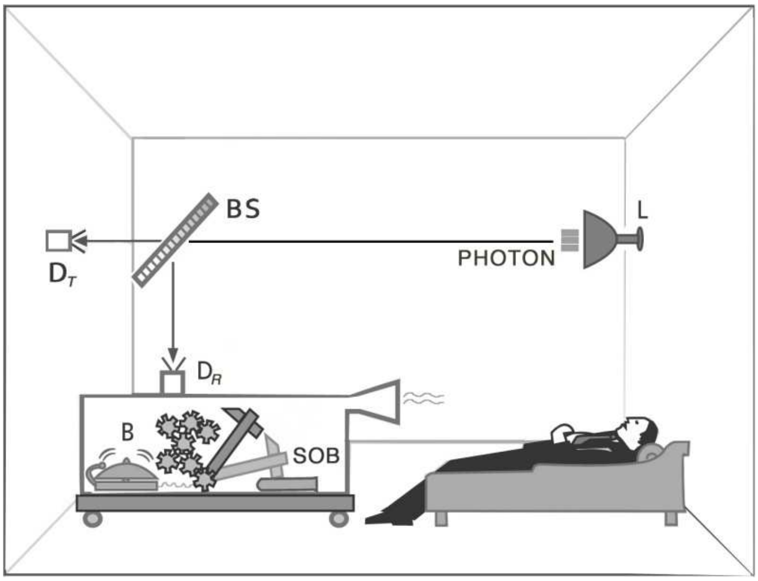

Fig. 2 The Copenhagen interpretation of QM would describe the system in superposition of the states | **P** unconscious in the silent room> + |**P** unconscious in the noisy room> in the interval of time between 2:00 + Δt_1 and 3:00 PM-

Up to just before 3:00 PM, no information is available to **P**.

3.1 Three remarks regarding the experiment

(i) - The expedient of the **TCB** has a fundamental function. In fact, supposing that it were not used, according to the CCCH **P** would cause the collapse of the WF precisely as soon as he realizes to perceive or to not perceive a noise.

(ii) - Equation (2) describes a quantum superposition of two distinct macroscopic states in the interval of time between 2:00 + Δt_1 and 3:00 PM (figure 2). Note that, under the CCCH, the collapse of the WF requires that one of its two branches be eliminated by a conscious observation, but in this experiment, as already mentioned at the end of the previous section, **P** will be the only observer.

(iii) - Human beings have access to their own internal states, perhaps similarly to cats or other animals, but, differently from these, they have the faculty of making very sophisticated analytical thinking due to their cumulative culture.

4 The UCP experiment disproves the consistency of the CCCH

Up to just before 3:00 PM there is no conscious being in the game, and Wigner would say (consistently with my assumption of **TCB** and his views about reduction) that the superposition is there, as depicted in figure 2. Precisely at 3:00 PM **P** becomes conscious either in the **SR** or in the **NR**.and his consciousness reduces the WF.

But such a statement is wrong! **P** reflects for a while before explaining why through an appropriate analysis.

Since the CCCH implies by definition a causal connection between two events, i.e. "the appearing of **P**'s consciousness" and "the collapse of the WF", **P** will examine whether, in the context of his experiment, there is a way to disprove the former as a causal agent of the latter**.** Hence, in order to achieve his goal, **P** will adopt a line of reasoning putting forward two relevant points:

First, if **P** considers any QM experiment, particularly Schrödinger's cat, Wigner's friend or similar versions, it is evident that the experimenter, aiming at acquiring knowledge of the actual outcome, has to perform an intentional observation/measurement that, according to the CCCH, collapses the wave function and, therefore, the observer's consciousness is supposed to play an active role on the physical world situated outside her/his mind.

Still, it is clear that the above point does not fit the UCP experiment simply because **P**, in view of the introduction of the **TCB** stratagem, does not play an active role as stated in the CCCH. In fact, **P**, as soon as conscious at 3.00 PM either in the **SR** or in the **NR**, is neither in the same situation of the observer who deliberates to open the Schrödinger's box for verifying the state of the cat, nor in the same status of attentiveness of Wigner's friend[7] when checking whether he did or did not perceive a flash.

Second and crucial argumentation: if you were a supporter of the CCCH and claimed that the collapse occurs precisely when **P** regains consciousness at 3:00 PM, for example, in the **NR**, you would be led to conclude that the two events - the appearing of **P**'s consciousness and the WF collapse, thought to be respectively the *cause* and the *effect* - occur *simultaneously*:[8]

This particular situation deserves to be investigated carefully, because it is radically different from all other quantum experiments in which the conscious observer is supposed to play an essential role in bringing about the collapse of the wave function.

In the UCP experiment, there are two distinct events that **P** acknowledges precisely at 3:00 PM: the appearing of his consciousness (**C**), and his perception of **NR** or **SR.**

Since **P** experiences both the events **C** and **NR** (or **C** and **SR**) at the same time, a *causal order* between **C** and **NR** (or between **C** and **SR**) is not logically admissible, because **P**'s consciousness cannot take place before the **NR** or the **SR** . Therefore, the CCCH, which should imply a causal order such as **C → NR** (or **C → SR**), is not tenable.

To this end, **C** and the **NR** (or **C** and the **SR**) are clearly two events independent from each other and **P** undergoes both of them precisely at 3:00 PM, as soon as the **TCB** effect is finished.

Finally, **P** is certain that his consciousness cannot have appeared before 3:00 PM and also that it cannot have caused the collapse of the WF. Thus, the **NR** (or the **SR**) does not represent the collapse, but simply the fortuitous outcome. Indeed, this is the case in which the **NR** (or the **SR**) and **C** must have been two different *effects* which, although both experienced by **P** at the same time,

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[7] Wigner's friend, here called "**F**", is a physicist left alone inside a laboratory with the task of checking *attentively* whether or not a detector has emitted a flash (has registered the arrival of a photon or not). Wigner is waiting outside and suspects that **F** (as well as all other human beings) may have weird perceptions and be in the superposition of macroscopically distinct states |**F** has perceived a flash> + |**F** has not perceived a flash>. Finally, Wigner enters the lab and asks **F** whether or not he perceived a flash. His reply (yes or no) should remove any doubt as to whether the wave-function collapse has occurred. However, Wigner will question whether it is acceptable or not to establish that the collapse into one only of the two possible alternatives is determined by his action (his request and reception of an unambiguous answer). He poses this question since his initial way of interpreting the state of the system gives rise to a rather embarrassing paradox, from which he has three possible ways of escape: 1) accept a relative form of *solipsism*, in the sense that he believes to be, among all living creatures, the only one who has unambiguous perceptions, 2) assume that QM is an incomplete theory, 3) assume that QM is not applicable to human beings; he refutes solipsism and, being a firm supporter of QM completeness, opts for the last solution, assuming that there are beings, at least human beings, endowed with *consciousness* that constitutes an ultimate reality and plays an active role in determining the measurement process by rules that are not susceptible to scientific description.

[8] The question of causality is problematic, since it requires a distinction between the subjective and the objective aspects of this concept. Causality entails another (arguable) question called "cause and effect simultaneity", which has been discussed and investigated in depth by several philosophers, such as I. Kant, D. Hume, G.W. Leibniz and, recently, by Donald Gillies, Jay F. Rosenberg, Sylvain Bromberger et al.; for a detailed understanding see Buzzoni M.: *The Agency Theory of Causality, Anthropomorphism, and Simultaneity*, section 6, published online: 29 Jan 2015, https://doi.org/10.1080/02698595.2014.979668.

should be the consequences of the collapse occurred before 3:00 PM, reasonably when either D_T or D_R registered the arrival of the photon,

Summing up, given the state '**P** conscious in the **NR**' or the state '**P** conscious in the **SR**', that's it! That is simply the random o*utcome* acknowledged by **P** as soon as the **TCB** effect is gone.

5 Conclusions

All the above considerations have led me to conclude that, in this experiment based on the **TCB** stratagem, the *collapse* of the WF can neither take place at 3:00 PM nor later. That is to say that the collapse *is independent of the observer's consciousness* and that the CCCH, as explained in the previous section, is logically inconsistent, despite a recurring conviction that it is not falsifiable; see for example J. Acacio de Barros and Gary Oas [28].

If my analysis is accepted as well-grounded, a supporter of the idealistic interpretation of QM should rely on an alternative interpretation of QM, in which the role of the conscious observer, who is required in all scientific experiences, is merely relegated to acknowledge the experimental results.

We immediately understand that these conclusions have further implications, such as:

(**a**) - the concept of "collapse of the WF independently of consciousness" emerges from the *logical structure* of this thought experiment based on the **TCB** strategy, since it allows to see in a new light the relationship between subject and object of observation (as explained in section 4);

(**b**) - if it were not conceivable an experiment capable of disproving the CCCH, this latter would still represent a possible and, for a few physicists, an even more suitable alternative to other interpretations of quantum mechanics.

(**c**) - in the realistic QM theories based on the collapse postulate, *the* boundary between quantum and classical systems should now be reasonably *rescaled down* to the transition point between the quantum system described in (1)] and the initial (uncertain number of) atomic components of the photo-detector with which it interacts at 2:00 + Δt_2 PM (where Δt_2 is the travelling time of the photon WF from L to D_T and D_R);

(**d**) - in the collapse theories *Schrödinger's cat* experiment can no longer be considered a paradox: before opening the box, the cat (as well as **P** in the UCP experiment before regaining consciousness) is in a statistical mixture of states;

(**e**) - the falsification of the CCCH rules out also the hypothesis that the collapse of all the wave-functions involved in our Universe (according to the hypothesis shared by many scientists that consciousness is regarded as an emergent phenomenon) occurred when the first conscious human being appeared in it, thus avoiding to render the big-bang a senseless theory;

I think that the validity of my argument is tenable with regard to one central hypothesis: the fact that, in certain controlled circumstances, *conscious perception* phenomenon, including self-awareness, could be *suspended* in a human subject. In other words, there could be an interval of time during which the subject is totally deprived of *self-awareness and the faculty of consciously perceiving* signals coming from external surroundings. While this assertion may probably be open to doubt from a philosophical point of view, it appears sufficiently backed-up by common sense (and also by certain experiential data).

In synthesis, the starting point of my work is that the idealistic interpretation requires the superposition of macroscopically distinct states as well as the conscious perceptive faculty of the observer. This is necessary for consciousness to play a fundamental role in the collapse of the WF.

Nevertheless, it is possible to devise at least a thought experiment (e.g. the UCP), which disproves the hypothesis that it is the observer's consciousness that causes the collapse. If this is shared as logically compelling, then one is left with the immediate issue of what the best alternative to the idealistic interpretation should be, and clearly this is an entirely different (and daunting) problem.

However, I feel that the ordinary idea behind the UCP experiment is that there are two ingredients given by the *wave function* and the observer's consciousness, which cannot in general be clearly separated, at least in such a way as to make the latter a causal agent in the collapse of the former. If this is true, then a fruitful way to tackle the measurement problem can only be one that treats the above two ingredients in a single coherent framework.

Recent advances in the quantum de-coherence and a re-examination of Everett's Many Worlds Interpretation suggest that such a framework could be constructed entirely within the boundaries of the theory itself; see, for instance, Roland Omnès [29], Maximilian Schlosshauer [30] and David Wallace [31], but clearly this is not the only route; see also Bernard d'Espagnat [32]and the very recent works of Carlo Roselli, Bruno R. Stella [33] and Art Hobson [34-35].

Furthermore, the UCP experiment, for being capable to disprove the consistency of the CCCH, could represent a good reason for strengthening some of the actual quantum mechanical spontaneous localization models, where observers have no special role: I am referring to Ghirardi, Rimini and Weber theory (GRW), to Penrose and to Hameroff-Penrose interpretations, in which the WF is assumed to be as a physical reality and its collapse as an objective dynamical process, that in Penrose's approach is supposed to be induced by gravity.

I would like to close this paper quoting a sentence by Steven Weinberg [36, p. 124]:

"*I read a good deal of what had been written by physicists who had worried deeply about the foundations of quantum mechanics, but I felt some uneasiness at not being able to settle on any of their interpretations of quantum mechanics that seemed to me entirely satisfactory*".

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