Can Schrodinger's Cat Be Really a Quantum Touchstone?

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ABSTRACT

It is revealed the invalidity of the idea that famous Schrodinger's cat thought experiment can be a quantum touchstone. The arguments are: (i) the probabilistic incorrectness in the (over)rating of the subject, (ii) the possibility of imagining non-quantum scenarios but completely similar to that experiment (iii) lack of ratified practical tests having genuine essence (i.e., non-counterfeit). So, the aforesaid experiment appears as a simplistic thought exercise without any notable significance for quantum physics.

Keywords: Schrodinger's cat, thought scenarios, random variables, single realizations, statistical evaluation.

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I. INTRODUCTION

In its original version, the famous thought experiment with Schrodinger's Cat (SC) is a quantum scenario, i.e., an imagined sequence of possible events, one of which has a quantum nature (see [1], [2]). Regarding its significance/importance, within mainstream publications and scientists, one encounters the next Widely Agreed Idea (WAI): *"The Schrdinger's cat thought experiment remains a defining touchstone for modern interpretations of quantum mechanics"* [2]. But surprisingly, the mentioned WAI has a groundless character. This because it is accepted without having any evidence/support, of experimental or theoretical nature, for its truth or usefulness. That is why it becomes interesting to search for elements/arguments able to test the viability of the respective WAI.

A search of the alluded kind is aimed in this article. Firstly, we will point out the essential characteristics of SC quantum scenario. Then, for SC, we propose to imagine two non-quantum scenarios whose main characteristics are completely similar to those of the quantum ones. But such characteristics and similarities contravene and repudiate indubitably the discussed WAI. Even the imagination of some virtual statistical constructs based SC scenarios cannot bring viable arguments in favor of that WAI. Also, for the aforesaid quantum scenario, in literature, it is signaled the absence of ratifying real tests.

Consequently, the original quantum Schrodinger's cat scenario cannot be regarded as a real quantum touchstone (or reference criterion). Moreover, the respective scenario is revealed as being a simplistic thinking exercise, without any appreciable relevance for physics.

II. ESSENCE OF THE ORIGINAL QUANTUM SCENARIO

The crucial element of the original SC scenario is represented [1], [2] by *"a tiny bit of radioactive substance, so small, that perhaps* **in the course of the hour one of the** **atoms decays, but also, with equal probability, perhaps none"**. (Within more publications from last decades, the respective "tiny bit" is replaced with "a single atom" which in fact means "an alone nucleus"). Through a sensor (Geiger counter), the decay, as a priming element, initiates a macroscopic killing device that can act on a living cat situated within a box completely closed (and obscured towards external observations). Associated to the respective scenario, as an illusory task for a theoretical evaluation, it was promoted the Unworkable Question UQ_1: *"In what state of life (alive or dead) is the cat at the end of the mentioned hour?"*. Until today, for the mentioned question, no answer was found within predictive-theoretical quantum approaches. So far, for the alluded question, only a non-theoretical approach seems to remain able to provide a pseudo-answer, by a macroscopic empiric opening of the box. But as regards the aforesaid question UQ_1, most scientists appear to desire and search for an answer solely through a theoretical quantum route. Such a desire is pointed out by the Widely Agreed Idea (WAI): *"The Schrodinger's cat thought experiment remains a defining touchstone for modern interpretations of quantum mechanics"* [2]. Of note, however, is the fact that the respective WAI has an unjustified character. This because, concretely, it is not founded on any argument, of experimental or theoretical-conceptual nature. Of course, for an opinion, as is the above-alluded WAI, it is necessary to analyze whether exist or no adequate founding pieces of evidence.

An analysis of the mentioned kind requires firstly to focus attention on the essence of the SC quantum scenario. The respective essence is connected with the fundamental aspect that [3] the radioactive decay is a random process. Such a process is characterized by a random variable known as the lifetime *t* of the specific atom (nucleus). Then, in regard to that variable, detection of a unique disintegration at a certain moment is nothing but a "single realization" (for the here assumed meaning of terms see the below APPENDIX). The detection is supposed as being done by check of life state for

the cat, and the moment is exactly one hour after the beginning of the experiment – i.e., just at the half-life $T_{1/2}$ of the involved atom. On the other hand, within a genuine probabilistic view, a random variable has to be evaluated not through a single realization given by an alone trial but by an appreciable set of such realizations. Based on the respective set, for practical purposes regarding the mentioned variable, can be computed some suitable statistical/probabilistic estimators (the respective estimators are reminded briey below in Section IV).

Due to the above-mentioned aspects, the usual and prevailing interpretation of the SC quantum scenario proves to be completely wrong. This because in regard to the evaluation of a random variable (physical observable) it is grounded on the substitution of a genuine statistical estimation by a single realization. The respective substitution is directly guilty for the usage of the illusory question UQ_1 and also for the whole conception centered around the mentioned WAI. So, the respective question becomes totally inadequate while WAI loses its credibility.

III. TWO EXAMPLES OF NON-QUANTUM SCENARIOS

Similar substitution of a natural statistical estimation with a single realization, in cases of physical random variables, can be imagined also for nonquantum (macroscopic) SC scenarios. Such scenarios may be conceived as sequences of events, none of which have quantum features. Within below proposed non-quantum images, an SC scenario comprises the same components as in the quantum version, except the priming element and associate sensor.

For the **First Example** of an alluded non-quantum scenario let us regard [4] the case of an SC threatened by the launching of a single macroscopic ballistic projectile. Thus, as a priming element can be considered the reaching of such a single projectile in its hitting point. The associate sensor can be imagined as being an unobservable macroscopic detector covering a surface where the hitting point of a projectile is expected to appear in 50% of cases (the surface with the mentioned characteristics is known in military science of ballistics as "circular error probable" [5]). The sensor acts in an unobservable macroscopic manner on the killing device which can murder the cat. Moreover, we consider solely the case with the launching of a single projectile for which can be monitored only the flight time but not the spatial position (or form) of its trajectory.

Note that, from a probabilistic perspective, a large number of individual projectiles, but similarly launched, is characterized by a true random variable which is the position vector $\vec{r}$ (x, y) of hitting point (located in an XY plane). Conjointly, the arrival of a single projectile at its point of impact appears as a single realization of the respective variable. As an illusory task for theoretical evaluation, the above presented non-quantum scenario can be supposed as entailing the next unworkable question UQ_2: *"What is the cat state of life (alive or dead) at a given moment after the flight time of the single projectile?"*. Here it should be noted the fact that an answer to UQ_2 cannot be given by theoretical methods of classical physics, not even through the laborious variants of known ballistics. Again, for the alluded question, only a non-theoretical approach seems able to provide a

pseudo-answer, through an empiric (macroscopic) opening of the box.

Now we have to specify the following observation. The above imagined non-quantum SC scenario implies also the usance of a single realization as substitute for a natural statistical estimation of a random variable (namely of vector $\vec{r}$). The above-noted observation reveals the complete similarity of the respective scenario with the quantum one.

As a **Second Example** from the announced non-quantum scenarios, we consider an experiment dealing with the dropping of a single ball across the Galton board (known also as bean machine [6]). Thus, the role of the priming element is played by dropping from the board top of one single ball. The associated sensor may be an unobservable macroscopic system placed in one of the collecting slots of the device, say in the slot with number k having the coordinate x_k (in relation with an Ox axis). The said slot is characterized by the probability p_k that, from a large number of individual balls, a ball falls into it. The accompanying sensor is able to act in a hidden non-quantum (macroscopic) manner on the killing device which can murder the cat (situated in a box similar to the one from the original quantum SC scenario).
In such a Galton-type single experiment, all the collecting slots, supposed as being obscured for external observations, are characterized by the set of coordinates x_j (j=1,2,...,n). The respective set represents the spectrum of a discrete random variable x which will be called coordinate. Then a falling of a single ball in a particular slot with number k denotes a single realization of the mentioned variable.

Connected with the here specified experiment, as an illusory requirement for theoretical evaluation, it is possible to advance the following unworkable question UQ_3: *"Is the cat dead or alive after the falling of the considered single ball?"*. Such a question is completely similar to the UQ_1 one appearing in the case of the SC quantum scenario. For the question UQ_3 mentioned above, no theoretical answer can be found by using the laws of classical physics (mechanics). Again, only an empirical approach seems to remain able to provide a pseudo-answer, through an empiric-macroscopic opening of the box that imprisons the cat.

The main observation induced by the above Galton-type SC scenario is the following one. A presumed answer concerning the life state of the cat, regarded as an estimation of the random variable x is built essentially on the idea of substituting a natural statistical evaluation by a single realization namely by the falling of a single bead in the particular slot of number k. But the just noted observation reveals the complete similarity of the here discussed non-quantum SC scenario with the original SC scenario analyzed above in Section II.

IV. AN APPROACH IN GENUINE STATISTICAL TERMS

The above-discussed SC scenarios imply evident similarities. All of them aim at similar theoretical estimations for matters of practical interest (namely the life state of considered cats). Those estimations are proposed to be done through single realizations of the corresponding random variables t, $\vec{r}$ and x. But, scientifically, for a random variable, a single realization is completely insufficient in order to give

a practically useful evaluation. Such an evaluation requires some overall statistical estimators defined in terms of mathematics [7]. As examples of aforesaid estimators can be quoted: (*a*) the extensive ones like the entire spectrum of specific values or the percentage with which a certain part of the spectrum appears in a set of experiments, respectively (*b*) the cumulative ones as mean value, variance, or higher-order moments. Accordingly, due to the just mentioned aspects the alleged questions UQ_1, UQ_2 and UQ_3 prove themselves as being illusory requirements in regards to the corresponding SC scenarios.

Due to the just noted considerations, the previously described SC scenarios do not have the qualities of true scientifpc topics. Nevertheless, in principle, starting from the mentioned scenarios can be imagined some virtual statistical constructs, which may have certain scientific characteristics. Such constructs, for the same random variables t, $\vec{r}$ and x, can be able to deliver scientific approaches/evaluations through some overall statistical estimators. For the announced constructs, it should consider statistical assemblies, corresponding to each kind of the mentioned scenario. Every one of such assemblies must comprise a large number (statistically significant) of identical copies. It can be imagined through a successive repetition or by a set of imitative specimens. (In cases with repetitions, if the cat dies, it must be replaced with a live one).

Note that, associate with the statistical constructs imagined as above, for the random variables t, $\vec{r}$ and x, can be attached theoretical probabilistic distributions (based on hypotheses, models and mathematical reasonings). Thus, for the assembly centred around the variable t, one can use theoretical considerations regarding the description of radioactive decays. So, as it is well known [3], if the implied atoms are characterized by decay constant λ the elementary probability that a decay to occur within the time interval $(t, t+dt)$ is $dp = \lambda \cdot exp\,(-\lambda t) \cdot dt$. In case of the statistical construct regarding the variable $\vec{r}$ the corresponding theoretical probabilistic distribution can be obtained [5] starting from the so called "circular bivariate normal distribution". Relatively to the statistical assembly characterized by the variable x the associate theoretical probabilistic distribution can be introduced [6] by means of known "binomial distribution".

The above-imagined assemblies (statistical constructs) can be regarded as measuring setups. They refer to investigated random variables and to the measuring kits. The aimed variables are t, $\vec{r}$ and x defined as above in Sections II and III. A measuring kit comprises an associate sensor, a killing device, and a cat. The cat plays the role of a recorder which can be "read" (by the observer) through a macroscopic opening of the box.

In cases of the three types of measuring assemblies, the "readings" about the life state (alive or dead) of the cats provide statistical collections of single realizations appropriate to the measured random variable t, $\vec{r}$ or x. Those realizations give the primary data regarding the investigated variable.

Based on the mentioned data, by using adequate mathematical methods, for the considered variable can be computed the values of some overall estimators as the ones quoted above in this section. The respective values are exactly the ones that can give knowledge of practical utility and for scientifically rational inquires. In the due context, an example of such inquiry that can be formulated is the next Correct Question CQ:

"In what percentage, from a given measuring setup, at recording moments as in the scenarios discussed in Sections II and III, the cats are found dead".

The corresponding answers to CQ depend on the kind of involved measuring setup, associated with one of the random variables t, $\vec{r}$ or x. So, let us firstly concern with measurements of ideal type (i.e., without errors). Then the alluded percentages will: 50 % in case based on quantum decays, 50 % when one refers to launching of macroscopic projectiles, and respectively $p_k \cdot 100\%$ when deals with Galton boards.

Now note also an additional result regarding the measuring setup based on radioactive decays. The above-marked percentages refer to the implicitly specified recording moment i.e., to the instant of half-life $T_{1/2}$. But for the same setup, the percentage of dead cats can be estimated also for other instants of time. So, for the moment $\tau \neq T_{1/2} = = ln\,2/\lambda$ it is easy to show that the associate percentage is given by the expression $[1 - exp\,(-\lambda\tau)] \cdot 100\,\%$.

The above precised percentages, regarded as answers to the mentioned CQ, refer only to the ideal situations in which the measuring kits do not induce errors in the provided data. But from a correct scientific perspective it must be taken into account the aspect that, in reality, the alluded kits generate non-null measuring errors. That aspect regarding the measurements of quantum decays is known and studied in the scientific literature (e.g., in [9], [10]). Also, for other kinds of random variables (of nature both quantum and non-quantum), it was already investigated [4] the theoretical description of measuring errors (considered as alterations within data/information transmission processes). The here noted aspects about measuring errors can suggest a complementing view. Namely, for a more adequate theoretical description of aforesaid imaginative constructs, based on SC scenarios, it should investigate also some additional elements regarding the specific measuring errors. Such investigations exceed nevertheless the aims of the present article.

It should be noted now that, the above outlined statistical approach highlight once more the following fact. Due to their hypostasizes of probabilistic single realizations, the SC scenarios discussed in sections II and III have no veritable scientific value. Particularly the original SC quantum scenario is completely devoid of such a value.

V. Lack of Certifying Tests

The SC experiment imagined by Schrodinger is a hypothetical scenario expectable to be integrated within the ratified scientific structures. But, according to known and accepted rules, such integration requires that the respective scenario be tested experimentally in controlled conditions wherever possible. Then it is a surprising fact that no test of the mentioned kind was ratified until today. That fact is pointed out by the next notifications

(1) *"Schrodinger's Cat" was not a real experiment and therefore did not scientifically prove anything. Schrodinger's Cat is not even part of any scientific theory* [11].

(2) The Schrodinger's thought experiment is: *"a purely theoretical one, and the machine proposed is not known to have been constructed"* [2].

The last notification (2) is accompanied by the specification: *"However, successful experiments involving similar principles, ..., have been performed"*.

But observe the fact that aforesaid experiments, in regard to random variables, seem to refer mainly to situations with huge numbers of events but not to a single trial as in the case of the original SC scenario.

Based on the notifications and fact pointed above one can say that, in reality, there is an authentic lack of certifying tests for the discussed SC quantum scenario.

VI. CONCLUSIONS

Now let us return to our starting question if the Schrodinger's cat can be really a quantum touchstone. For an answer to the respective question let us summarize the main elements revealed in the above discussions. The respective elements are summarized by the next argumentative remarks:

a. The usual interpretation of the original quantum SC scenario (regarding in fact an evaluation of a random variable) is wrongly grounded on the substitution of a genuine statistical estimation with a single realization.

b. Comparatively, with the mentioned quantum scenario, can be imagined two other scenarios completely similar but of non-quantum essence.

c. In a genuine probabilistic approach, the above-discussed SC scenarios (quantum as well non-quantum ones), being in fact single realizations, are completely devoid of true scientific characteristics.

d. The considered SC quantum scenario is completely deprived of true certifying experimental tests.

Now, by taking into account the above argumentative remarks (a), (b), (c) and (d) one can conclude that the SC scenario, in its original quantum version, proves oneself to be not an authentic scientific topic. Consequently, the respective scenario cannot be really a quantum touchstone. Plainly, the above noted direct pieces of evidence contravene and eradicate in an indubitable manner the WAI mentioned above in Section II. So, it results clearly an argued negative answer to the question from the title of the present article.

Moreover, regarding the root of here discussed matters - i.e., the original SC quantum scenario, one can say that it appears as simplistic thinking exercise, having no significant importance for quantum physics.

APPENDIX

In this article, partially inspired from the known terminology [8], the phrase "single realization" is used with the significance of a *"value that is actually observed in a particular experiment (single trial) regarding a random variable"*. In our papers ([4] and previous ones) the same mentioned significance was depicted through the syntagma "single sampling". Here we have changed the depiction because of the following considerations. In many publications, the term "sampling", besides its reference to a unique experiment (trial), has often another meaning. Namely, the term "sampling" is regarded also as a selection of a representative part (i.e., a set of elements) from a statistical population**.**

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