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OBSERVING IN PHYSICS AND IN ARTS*

A OBSERVAÇÃO NA FÍSICA E NAS ARTES

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Abstract:

How do we as observers disentangle ourselves from the observed? In Quantum Mechanics physicists can not disentangle themselves from what they observe. The problem becomes: how do physicists interpret their entanglement with observations in their experimental situations? Parallel questions occur in the arts. How does the audience disentangle itself from their observations of the work of art? We cannot. The problem becomes: is the work of art actually completed by the audience's observations?

Keynotes: Quantum Mechanics, History of Physics, Visual Arts, Observation

Resumo:

Como é que nós, como observadores, nos desenredamos do observado? Na Mecânica Quântica os físicos não se podem desembaraçar daquilo que observam. O problema torna-se: como é que os físicos interpretam o emaranhamento com as observações nas situações experimentais? Qestões paralelas ocorrem na arte. Como é que o público se desembaraça das suas observações da obra de arte? Não podemos. O problema torna-se: a obra de arte é realmente completada pelas observações do público? Nesse sentido, arte e ciência apresentam um paralelo interessante no se que refere ao papel da observação na constituição dos seus objetos e realizações, que Sheldon Richmond explora em seu artigo.

Palavras-chave: Mecânica Quântica, História da Física, Artes Visuais, Observação

The questions of whether and how the observer contributes to the work of art and to the scientific experiment are parallel. The general background question is whether and how the observer influences reality. The question is: Is what is out there totally independent of us as observers? Or, is what is at least influenced by our observations? The general question may be unanswerable. The answerability of the general question has to do with the perennial

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philosophical metaphysical quest of attempting to find a decisive test outside of our theories of reality that will definitively distinguish between illusion and reality. It is impossible to find such a key because the key itself is of our own making. However, I think the specific applications of the questions in physics and in the arts are quite answerable.

In short, the fundamental nature of the problem of the observer is: does observing influence the results of experiments in physics and influence the work of art in the

Physics

The first question, one can ask here, concerns the problem of theory-influenced observation: every observation is made from the point of view of a theory or at least a question, and the question is asked with various assumptions and background theories. If every observation is 'theory-laden', how can we use observations to test theories?

The second question, one can ask here, concerns the problem of the selectivity of the observer: every experimental situation depends on the choice of a frame of reference, and experimental equipment. Hence, every observation is biased by the activities and choices of the experimenter or observer. How can we observe the selection of reality sufficient to our questions without biasing the experimental results in favour of our expected answers?

The third question, one can ask here, concerns the problem of the physical role of observation in Quantum Mechanics (QM) — the observer influences the nature of what the observer is observing in the experimental situation. How do we disentangle the product of our observations from what we are observing, and if we can't, is the mathematical formalism of QM merely a representation of the measurements of the observer?

I focus on the third question of disentangling the products of our observations from what we are observing in QM.

To explain the question of the observer in QM, here is a thought-experiment. Imagine we are in a room together, at a session in a conference or in a classroom, where I am reading a paper to you. In this imaginary session, I, the reader of a conference paper, am wondering the following: I am wondering what you may be wondering, what my paper is really about, and what my central questions are in this paper, and even wondering whether I have any questions and whether my questions are new or at least interesting. Also, you may be wondering whether I have any new answers to my questions. "Does this person up there have anything to say that we have not heard a dozen times before, and at least 6 times before at this conference?".

In other words, in this thought-experiment or imaginary situation, we are in a social system where you are the observer of an observer of you as an observer of an observer observing you. Or, you are in a social system where there is an observer observing you, and you are observing the observer. Or, I am in a social situation where there are observers observing me observe them.

But our individual existences, and the existence of this entire social system is independent of our observations, unless, of course this social system itself as a physical system is observed by an outside observer. More precisely speaking, this social system may contain another observer who we do not happen to observe but who observes us and so the social states in this system depend upon the observations of this observer, who forms a new system with that observer as part of the system, but independent of our observations of that observer. In short, the point of the thought-experiment or imaginary-situation is that observations about observations, or observers observing each other, are entangled: they influence each other. This basically, is the fundamental concern of QM concerning the role of observation: how to work with entangled observations.

Is this concern of QM about how observing in physics involves dealing with observations entangled with the experimental situations and the situations of other observers observing experimental situations, radically new? Can we in any way use what we learn from the history of physics about observing, to help us understand how QM works with the entanglement of observing?

Mendel Sachs (1927–2012), I observe, has an interesting perspective on the issue of whether the history of physics is continuous with physics today including how observing occurred historically in physics:

> It appears to me as a professional physicist that the ideas of science in each period did not appear suddenly, totally disconnected from the preceding developments in the history of science. I believe that strands of truth about the physical world do persist throughout all of the so-called 'revolutions' in science, and that real progress is evolutionary rather than revolutionary. It is the continuation of these strands of truth through the different periods of history of science that characterizes actual progress in our understanding of the physical universe. Of course, history does reveal that changes in scientific ideas often occur over short periods of time. Such rapid evolutionary change, though still connected with some of the ideas of the past, then gives the illusion of a genuine revolution of ideas, a complete break with the past. But a closer look reveals that it is indeed evolutionary, after all.[2]

[2]SACHS, Mendel. **Einstein versus Bohr: The Continuing Controversies in Physics**. La Salle, Illinois: Open Court, 1988; pp. 1-2.

Using the perspective of Mendel Sachs, we can observe the following: the Copenhagen Interpretation with respect to the issue of the role of the observer in physical systems, has evolved and is continuous not only with Albert Einstein's (1979-1955) theory of the role of the observer in Special and General Relativity, but also with previous physical theories such as Galileo (1564-1642) and Newton (1642-1727), if not back to Plato (d. 348/347 BCE) and Aristotle (384-322 BCE), or Thales (d. c. 548/545 BCE) and the other pre-Socratics.

What is of paramount importance to the question of how QM is continuous with classical physics or previous physics is how QM treats the observer in physical systems. However, a critical reader might wonder that if "historical facts" are answers to the questions asked, then the "historical facts" pertinent to the question whether the history of QM is continuous or not with the history of physics previous to QM, depends on the questions that one asks. A critical reader might observe that if you ask questions about how QM is continuous with Special Relativity and General Relativity, then you will find continuities; or, if you ask questions about how QM is discontinuous, you will find discontinuities.

In any case, here are my observations (as an answer to the question of the continuity of physics): all physics since, at least, Galileo has a theory of the observer in physical systems to explain how appearances go wrong, and to provide a demarcation point for demarcating the relative from the invariant. Such a problem may even go back to Thales and at least Parmenides (early 5th c. BCE) or Zeno (d. c. 430 BCE), in demarcating the variant or relative (i.e. space and time, and motion) from the invariant, the universal and unchanging spheroid Being.

However, the observer in QM is radically different from the observer even in Special Relativity Theory. The observer in Special Relativity Theory only obtains different quantities by using classical measuring tools or classical experimental equipment in different inertial systems. The observers differ with respect to their results in measuring distance or simultaneity of events, because they are in different inertial systems in uniform motion relative to each other. In General Relativity, the observers differ in their results concerning measuring of mass because they are in different accelerating non-inertial systems relative to each other. However, the laws of physics that apply to those in differing uniformly moving systems are invariant – in Special Relativity. Also the laws that apply to mass, space, and gravity are invariant with respect to non-inertial systems in General Relativity. In other words, QM treats the observer in physics in a radically new way. It treats the observer as

follows: the observer in the observer's use of classically described experimental equipment, actually changes the quantity by the very act of measurement.

In QM, the observer has nothing to say about the reality or for that matter unreality of the measured event, or the "observable", only about the measurements or quantities. Either questions about the reality of the observable are outside the scope of physics, or reality is just what the observation is. The observation is the reality, and there is nothing else other than the observation. In more precise terms, the observable measured forms the knowledge of the observer, and when the observer does a measurement of the observable, the observable has quantities that vary with the choice of measuring equipment. To carry on with the situation of the observer in physical systems according to QM, regardless of the question of interpretation, but just in terms of the physics alone and in and of itself: whether the observer decides to measure the observable from the point of view of the locality of the wave function or the momentum of the wave function, or even whether to measure the observable as a particle using matrices according to Werner Heisenberg (1901-1976), or to measure the observable as a wave function using the wave function or psi-function formalism according to Erwin Schroedinger (1887-1961), all are mathematically and physically equivalent where what the observer is doing is describing the metric of the observable measured.

At this point, a critical reader might observe that I have forgotten the meaning and import of the fact that facts depend upon the questions we ask. I am asking to find the base point for QM free of the issue of interpretation. However, such a task is impossible because all facts are interpretations as tentative answers to our questions. So, we can't get to a QM base free of all interpretation because how we approach this supposed base depends upon the questions we pose to QM.

The short of it is that the two questions: first, how to interpret QM and the theory of the role of the observer in QM; and, second, how QM is continuous with previous physics, are entangled. I cannot do the impossible and find some statement of QM that is neutral. Moreover, I cannot even, if I were capable, present a mathematical formalism that is neutral to all interpretations because one needs to choose postulates, and the choice of postulates is influenced by one's interpretation. All that we can do is work with different observations or interpretations of QM, and how we observe that those different interpretations are discussed.

Let us start with Karl Popper's (1902-1994) statement:

> I attempt to exorcise the ghost called 'consciousness' or 'the observer' from quantum mechanics, and to show that quantum mechanics is as 'objective' a

> theory as, say, classical statistical mechanics. In the body of this volume, I shall attempt to substantiate my argument in somewhat greater detail, and to state my own understanding of these issues that have plagued quantum theory over the past fifty years, and my own alternative approach.
> ... the observer, or better, the experimentalist, plays in quantum theory exactly the same role as in classical physics. *His task is to test the theory*.
> The opposite view, usually called the *Copenhagen interpretation of quantum mechanics*, is almost universally accepted. In brief, it says *that 'objective reality has evaporated' and that quantum mechanics does not represent particles, but rather our knowledge, our observations, or our consciousness, of particles.*[3]

According to Karl Popper, on my observation, the Copenhagen Intepretation of QM has two components:

1. The observer does not merely need to test theories, but also influences physical systems and is fundamental to the nature of the physical system that the observer is supposedly observing. In other words, the observer is not neutral to or outside of the physical system, but is an essential component of the physical system;

2. The theories of quantum mechanics are not theories of a supposed independent reality but are theories of our consciousness or knowledge or observations.

Michael Redhead (1929-2020), at least as I read Michael Redhead, thinks that Karl Popper is too kind to the Copenhagen Interpretation. The Copenhagen Interpretation is too muddled to be taken seriously. In Micahael Redhead's own words, "The difficulty with assessing the complementarity interpretation", Redhead uses lower case in order to highlight his disdain and his own heterodoxy, "of QM is undoubtedly the fact that Bohr's own formulation of the general framework of his ideas is vague and ambiguous. From the methodological point of view, the main objection is the finality". Michael Redhead is referring to the issue of the completeness of QM which Bohr maintained and Einstein disputed

> with which Bohr prohibits even asking certain questions about QM systems. Complementarity was for Bohr a major philosophical discovery... Setting the dogmatic limitations on scientific theorizing, on the basis of obscure

[3]POPPER, Karl. **Quantum Theory and the Schism in Physics**. Totawa, NJ: Rowman and Littlefield, 1982 [1956]; pp. 35.

> philosophical preconceptions, is a dangerous prejudice from the standpoint of a conjectural-fallibist approach to the nature of scientific activity. It is for this reason that other approaches to the interpretation of QM are the main business of this book.[4]

Moreover, Michael Redhead goes on to say,

> So there it is – some sort of action-at-a distance or (conceptually distinct) nonseparability seems built into any reasonable attempt to understand the quantum view of reality. As Popper has remarked, our theories are 'nets designed to catch the world'. We had better face up to the fact that quantum mechanics has landed some pretty queer fish.[5]

Is Michael Redhead exaggerating the difficulty of understanding Niels Bohr's thesis of complementarity?

Let us return to Niels Bohr (1885-1962) to see whether Karl Popper and Michael Redhead are fair to him. Firstly because Niels Bohr set the stage for Karl Popper's own criticisms and own alternative interpretation, and secondly, because Niels Bohr set the stage for all other interpretations that I have come across – hidden variable, holistic, Roger Penrose's interpretation (2005), and Hugh Everett III's (1930-1982) the many worlds or Universal Wave Theory interpretation (1973 [1957]), to name only some of the available interpretations. All those interpretations, except for Michael Redhead's interpretation, seem to take Niels Bohr seriously, and so, I observe that I need to grapple with Niels Bohr's interpretation, not only for that reason, but also for the reason that I also want to find an answer to the question of how QM is continuous, if at all, with previous physics. If QM is continuous with previous physics, we can learn from previous physics about how observing works or at least, how observing has evolved throughout the history of physics.

Here is a very user-friendly version in Niels Bohr's own words of Bohr's own interpretation of QM:

> ….Heisenberg (1925) had laid the foundation of rational quantum mechanics, which was rapidly developed through important contributions by Born and Jordan as well as by Dirac. In this theory, a formalism is introduced [...] soon proved by Schroedinger to give results identical with those obtainable by the mathematically often more convenient methods of wave theory, and in the following years general methods were gradually established for an essentially statistical description of atomic processes

[4]READHEAD, Michael. **Incompleteness, Nonlocality, and Realism**: A Prolegomenon to the Philosophy of Quantum Mechanics, Oxford: Clarendon, 1987; pp. 51.
[5]READHEAD, Michael. *Op. Cit*, pp. 169.

> combining the features of individuality and the requirements of the superposition principle, equally characteristic of quantum theory [...]. The quantitative comprehension of a vast amount of empirical evidence could leave no doubt as to the fertility and adequacy of the quantum-mechanical formalism, but its abstract character gave rise to a widespread feeling of uneasiness. An elucidation of the situation should, indeed, demand a thorough examination of the very observational problem in atomic physics.
> This phase of the development was, as is well known, initiated in 1927 by Heisenberg, who pointed out that the knowledge obtainable of the state of an atomic system will always involve a peculiar "indeterminacy" [...]. In pointing to the intimate connection between the statistical description in quantum mechanics and the actual possibilities of measurement, this so-called indeterminacy relation is, as Heisenberg showed, most important for the elucidation of the paradoxes involved in the attempts of analyzing quantum effects with reference to customary physical pictures [...] I advocated a point of view conveniently termed "complementarity", suited to embrace the characteristic features of individuality of quantum phenomena, and at the same time to clarify the peculiar aspects of the observational problem in this field of experience. For this purpose, it is decisive to recognize that, *however far the phenomena transcend the scope of classical physical explanation, the account of all evidence must be expressed in classical terms.* The argument is simply that by the word "experiment" we refer to a situation where we can tell others what we have done and what we have learned and that, therefore, the account of the experimental arrangement and of the results of the observations must be expressed in unambiguous language with suitable application of the terminology of classical physics.
> This crucial point, which was to become a main theme of the discussions reported in the following, 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*. In fact, the individuality of the typical quantum effects finds its proper expression in the circumstances that any attempt of subdividing the phenomena will demand a change in the experimental arrangement introducing new possibilities of interaction between objects and measuring instruments which in principle cannot be controlled. Consequently, evidence obtained under different experimental conditions cannot be comprehended within a single picture, but must be regarded as *complementary* in the sense that only the totality of the phenomena exhausts the possible information about the objects.[6]

Here is how I read the above:

1. The observer in describing the experimental situation, which the observer uses for observational testing, must use the terms of classical physics;

[6]BOHR, Niels. "Discussion with Einstein on Epistemological Problems in Atomic Physics". In: SCHILPP, P. A. (ed.). **Albert Einstein, philosopher-scientist**. New York: Tudor Pub. Co., [1949] 1951; [pp. 201–241] p. 207-210 [reprinted in 1958, **Atomic Physics and Human Knowledge**, New York: Wiley].

2. The observer does not describe the observational situation or experimental situation in terms of QM;

3. The formalism of QM only applies to the "phenomena" that is observed through the use of the classically described equipment.

What does the situation of the observer of quantum phenomena using classically described experimental situations show us about the observer in QM?

Niels Bohr solves the problem of the role of the observer in QM by actually accepting a continuity between the observer in QM and the observer in classical physics and in relativity physics. All observers in those physical systems are subject to classical physical laws. However, the outcome of their observations differs with respect to the laws of physics that are applied. In the macro-world, our ordinary experiential world, we continue to apply classical physics; in the fast world approaching the speed of light, we apply relativity physics; and, in the quantum world of micro-particles and elector-magnetic dynamics, we apply QM.

If what Niels Bohr does is somewhat confusing, as Michael Redhead observes, who helps us out here: who can explain to us clearly the role of the observer in QM, and how that role relates to the role of the observer in classical physics? I suggest that Bohr's right-hand man, as it were, Leon Rosenfeld (1904-1974) might be of some help.

Basically, Leon Rosenfeld says that Bohr's interpretation is not an interpretation, or that the so-called "Copenhagen Interpretation" or what Bohr calls "complementarity" is not an interpretation of an externally existent or independent theory of physics and independent mathematical formalism, but at its core, it is just physics. Niels Bohr's theory of the observer in quantum mechanical physical systems is a physical theory, not something outside or independent of the physics of quantum mechanics, but part of the theory of quantum mechanics.

One interpretation of Leon Rosenfeld's remarks that complementarity is not an interpretation of quantum mechanics but is itself part of quantum mechanics is that Leon Rosenfeld is just providing a defensive measure for quantum mechanics that allows him to dismiss all criticisms, especially those criticisms directed at Niels Bohr's thesis of complementarity. Indeed this quote from Leon Rosenfeld, I observe, has a defensive character in attempting to explain away all criticism as due to the bad attitude of naïve students who are

incapable of honestly confronting or accepting the probabilistic or statistical nature of quantum mechanics:

> You see, when you first approach quantum mechanics, as a student, it is reasonable that your first effort is to understand the equations and how to handle them. And then you ask: what is the meaning of all this? And if you are for some reason afraid of statistics or of probability, then you ask yourself: could it perhaps be otherwise? That was David Bohm's way, actually. He gave a lecture on quantum mechanics (probably the first one that he gave on the subject) and he made a book out of it. This is a very good book, a very good exposition of quantum mechanics. But it was in the process of writing the book that he had doubts about the whole thing. However, his attitude was such that he put mathematics first and he tried to hand the physics onto the mathematics, without thinking that the natural process was just the opposite.[7]

To my mind, this criticism of David Bohm's (1917-1992) doubts and eventually alternatives to Bohr's interpretation of quantum mechanics does implicitly make an underlying valid point. The physics of the observer is part of quantum mechanics, no less than the physics of the observer is part of all physics. Only in quantum mechanics the physics of the observer involves statistics and probabilities. John Archibald Wheeler (1911-2008) is more explicit about this point in his own response to the questions of one of the interviewers in the book from which I quoted Leon Rosenfeld. John Archibald Wheeler recounts a conversation with Einstein. I will focus on John Archibald Wheeler's report of his own thoughts that he had in reaction to hearing from Einstein himself, Albert Einstein's famous and often repeated metaphorical comments about the impossibility of chance having a fundamental physical role:

> […] To me, this is a perfectly marvellous feature of nature. We had this old idea, that there was the universe out there, and here is me, the observer, safely protected from the universe by a six-inch slab of plate glass. Now we learn from the quantum world that even to observe so miniscule an object as an electron we have to shatter that plate glass; we have to reach in there; we have to put some equipment there and we ourselves have to decide whether we're going to put there something that will measure the position of that particle or something that will measure its velocity, and according to which we do, the future of that electron is changed. So the old word *observer* simply has to be crossed off the books, and we must put in the new word

[7]ROSENFELD, Leon *apud* BUCKLEY, Paul & PEAT, F. David (ed.). **Glimpsing Reality: Ideas in Physics and the Link to Biology**. Toronto: University of Toronto Press, 1995 [1979]; pp. 19.

> *participator*. In this way we've come to realize that the universe is a participatory universe. The question very much on our minds these days is whether this participatory character of the universe extends much further than that. Is this just the tip of the iceberg that we've seen at this stage in physics? Is it conceivable that, in order to make sense out of the mysteries ahead, we'll find ourselves forced to recognize the participatory character of the universe in a much deeper way than we now see.[8]

Are you thinking what I am thinking that this is an astounding shift in thinking from the complementarity thesis of Bohr without any acknowledgement at all of any shift in thinking? John Archibald Wheeler, on first glance, seems to be re-iterating Niels Bohr's responses to Einstein, and at the least, Leon Rosenfeld's response to David Bohm: these fellows, Einstein and Bohm, almost fall into existential despair when confronted by the statistical or probabilistic nature of QM. Rather, as Niels Bohr argues, the observer is at the heart of QM. However, John Archibald Wheeler goes one step further than Niels Bohr, or rather, many steps further. Wheeler's first step is to talk about the phenomena studied by the observer, and so affected by the observer, as an objective feature of the universe. His second step is to recommend getting rid of the word, "observer" and replacing it with the word, "participator". John Archibald Wheeler's third step in departing from Bohr and complementarity, is that there could be even deeper laws of the universe beyond current QM where participation is even at a more fundamental level than found when we attempt to measure micro-events.

So here it is: John Archibald Wheeler in attempting to explain and defend QM, and how the physics of the observer in QM works, develops a new theory of the objectivity of the observer in nature: the observer is integral to the very objective structure of the universe by participating in the universe. It has crossed my mind, that John Archibald Wheeler has not only provided a new interpretation of quantum mechanics, but also has provided a new metaphysical or philosophical interpretation of quantum mechanics, all in the guise of just reporting the facts of the situation in physics created by the development of quantum mechanics.

My point is that the problem of the role of the observer in systems, whether physical or social, occurs throughout the history of physical and social theory, and has a common structure. Here is the structure of the problem. If the observer participates in the system by the very act of observation, then the observer changes the system. But, if the observer, changes the system by the very act of observation, can the observer find invariants about the system

[8]WHEELER, John Archibald *apud* BUCKLEY, Paul & PEAT, F. David (ed.). **Glimpsing Reality: Ideas in Physics and the Link to Biology**. Toronto: University of Toronto Press, 1995 [1979]; pp. 90-91.

that apply to other systems? For instance, would an observer observing the observer in the system, be able to determine both how that observer participates in the system, and how the system has features or invariants that other observers would discover by participating in the system? But this question raises another question: can an observer who is being observed by another observer, observe the other observer observing the observer? Would both observers participate in a new system that can be observed by another observer, and so on *ad infinitum*, with each observer influencing the observed observer? If so, we can never get a complete picture of any situation where there is an observer in a system who is also being observed and who forms a system with that observer.

My description of the common structure of the problem of the observer in systems sounds extremely philosophical, almost irrelevant to the problem of the observer in physics, and especially irrelevant to the problem of the role of the observer in QM. However, I have found that this apparently philosophical way of describing the problem and a novel solution are presented by the inventor of the Many Worlds or Universal Wave Theory, Hugh Everett III:

> Isolated somewhere out in space is a room containing an observer, A, who is about to perform a measurement upon a system S. After performing his measurement he will record the result in his notebook. We assume that he knows the state function of S (perhaps as a result of previous measurement), and that it is not an eigenstate of the measurement he is about to perform. A, being an orthodox quantum theorist, then believes that the outcome of his measurement is undetermined and that the process is correctly described by Process 1.
>
> In the meantime, however, there is another observer, B, outside the room, who is in possession of the state function of the entire room, including S, the measuring apparatus, and A, just prior to the measurement. B is only interested in what will be found in the notebook one week in the future according to Process 2. One week passes, and we find B still in possession of the state function of the room, which this equally orthodox quantum theorist believes to be a complete description of the room and its contents. If B's state function calculation tells beforehand exactly what is going to be in the notebook, then A is incorrect in his belief about the indeterminacy of the outcome of his measurement. We therefore assume that B's state function contains non-zero amplitudes over several of the notebook entries.
>
> At this point, B opens the door to the room and looks at the notebook (performs his observation). Having observed the notebook entry, he turns to A and informs him in a patronizing manner that since his (B's) wave function just prior to his entry into the room, which he knows to have been a complete description of the room and its contents, had non-zero amplitude over other than the present result of the measurement, the result must have been decided only when B entered the room, so that A, his notebook entry, and his memory about what occurred one week ago had no independent

> objective existence until the intervention by B. In short, B implies A owes his present objective existence to B's generous nature which compelled him to intervene on his behalf. However, to B's consternation, A does not react with anything like the respect and gratitude he should exhibit towards B, and at the end of a somewhat heated reply, in which A conveys a colourful manner his opinion of B and his beliefs, he rudely punctures B's ego by observing that if B's view is correct, then he has no reason to feel complacent, since the whole present situation may have no objective existence, but may depend upon the future actions of yet another observer.
> It is now clear that the interpretation of quantum mechanics with which we began is untenable if we are to consider a universe containing more than one observer. We must therefore seek a suitable modification of this scheme, or an entirely different system of interpretation [...].[9]

The structure of the question of the observer in QM, according to how I read Hugh Everett III, is that the role of the observer in physical systems must allow for multiple observers, observing each other observing each observer's own physical system. Furthermore, according to Hugh Everett III, not only does the orthodox (Copenhagen) interpretation of quantum mechanics fail but also other interpretations fail, i.e. David Bohm's hidden variable, and Friedrich Bopp's (1909-1987) "stochastic process interpretation". But my point is that Hugh Everett III is clear about presenting a requirement for all theories of the role of the observer in physical systems. The theory must allow for more than one observer existing in the universe, and so, must allow for observers observing each other as part of physical systems.

To my eyes, QM requires explanations that include multiple observers observing each other, where each observer changes or participates in the reality that is observed. Do you see the same thing that I see? Do we as observers change what we observe, including other observers? Does this happen in the arts as well: does observing the work of art, a painting, a sculpture, a performance of music, a live play on a stage, a film, influence, change the supposedly completed work of art? Does just observing art change art? I take this up now in Part II.

II. The Arts

In the arts we are faced with a parallel issue to physics: we know that when we observe a work of art, not only do we bring our own tastes, cultural biases, and knowledge of history,

[9]EVERETT III, Hugh. "The Theory of the Universal Wave Function". In: DeWITT, Bryce & GRAHAM, Neill Graham (eds). **The Many-Worlds Interpretation of Quantum Mechanics**. New Jersey: Princeton University Press, [1957], 1973; pp. 4-6; and BARRET, Jeffrey A and BYRNE, Peter. The Everett Interpretation of Quantum Mechanics: Collected Works 1955-1980. New Jersey: Princeton University Press, 2012.

theory, and criticism; but also we bring our selves into the process of the work of art, because the involvement of the audience is part of the work of art after the artist completes the work of art. How people react to the smiling face of Michelangelo's (1475-1564) La Gioconda/Mona Lisa or to the atonal music of Arnold Schoenberg (1874-1951) or to Samuel Beckett's (1906-1989) “Waiting for Godot” or to Orson Welles's (1915-1985) “Citizen Kane” is part of the work of art itself. The problem is if my observation of the work of art is part of the work of art itself, how do I distinguish between what I idiosyncratically bring to the work of art as opposed to what the work of art brings to me and everyone else who observes the work of art?

A series of problems are generated by the fundamental problem of distinguishing between the observer’s role in the work of art, and the role of the work of art itself. Some of these problems are: how do we talk to each other about the same reality, the same work of art? When we apparently talk about the same work of art, are we? When you observe me observing La Gioconda, and talk to me about La Gioconda, does your discussion need to include my reactions as well as your reactions, and does my part of the discussion have to include both our reactions as well as my reactions of your reactions to my reactions and so forth, going on recursively until we lose sight of La Gioconda whatever La Gioconda itself is?

The history of the arts is not free of this recursive problem: does every new book or discussion of the history of one work of art have to include every discussion of that work, including possible reactions to its own reactions? In other words, the longer a work of art is around, the more audiences it has, and the more audiences of those audiences there are, the more layered the work becomes – so layered that we are unable to find the work of art itself or our own genuine, honest, naïve, fresh reaction. Our own reaction becomes determined, or at least, influenced by the host of reactions out there and that we come to know – so determined and influenced that we do not know what we honestly or genuinely feel about the work of art.

Do you like it? Do you like La Gioconda? I don’t know anymore because I have seen ‘it’ too often – that is, I have read too many critics, historical discussions, and seen too many prints, copies, images, photos, take-offs, borrowings, uses, references, allusions, and saw the original too long ago in a small crowded room. But did I see the original – not in its original time, place, and state? I saw it in a museum centuries later, after seeing images of it, reading about it, talking about it, and so on. How then can I have a genuine and honest reaction to ‘it’? What is ‘it’ to which I am reacting?

Let us do a thought-experiment. Suppose a Martian visited the earth, or these days we can imagine, not a Martian visiting the earth, but an artificial intelligence system with the capability of artificial general intelligence (AGI). The idea is that both the Martian and the

AGI know nothing of the experience of the work of art. In observing a work of art, could the AGI system or the Martian react to the work of art in a similar way as humans react to a work of art in observing a work of art?

I am guessing that the Martian visiting us can talk about physics but not about the arts. Why? In physics, we talk on a primarily intellectual level. Whereas, works of art totally depend on human creativity and reception. Works of art are intimately tied up with human emotion and even biology. However, in light of the debate about the interpretation of QM, we can no longer draw an absolute dividing line between physics and the arts. The observer in physics determines the event, and even the past, when the observer records the observation. Even on a so-called realist interpretation of QM, there is no denial, according to David Bohm, that the scientist is a player on the stage of reality, and needs to be accounted for, even in a deterministic approach to reality:

> We must not say that what is in being is just the universe without us. Rather, it is the universe with us in it. We are part of being and therefore when we observe something we may well change it. If this happens to a significant extent then we must remember that being includes us, our minds, our thinking, our actions and so on. Now in this sense Bohr made a very important contribution when he stressed that the observer plays both an active and a passive role, that we are both actors and observers on the stage of life. But this is not in contradiction with the notion that there is a life and there is a stage upon which we can act and observe.[10]

In parallel to the scientist, the artist is on a stage that observes the audience observing the artist, and observing the performance of the artist.

The thought-experiment with the Martian and the AGI system is off the mark in certain respects. Human emotion and human biology play a central role in creating and observing works of art, and play a peripheral role at best in physics. However there is a parallel between observing in the arts and observing in physics, especially in QM. The parallel between QM and the arts is this: in both, the observer observing plays a crucial role. The point of the parallel is that the artist and observer are on the same plane, and both participate in the work of art. As scientists, our observations influence the path of the particle and the reactions of the particle in the experimental situations where we measure particles, but when we go away, and don't interact with the quanta in experimental situations, we have no idea about the specific

[10]BOHM, David. "Remarks made in the discussion during the Sixth Session". In: KÖRNER, Stephan and PRYCE, M. H. L. (eds.) **Observation and Interpretation in the Philosophy of Physics: With Special Reference to Quantum Mechanics**. New York, Dover Publications, 1957; pp. 184.

paths and reactions of particles. However, when no one is around to appreciate the arts, there is no reality for the arts. Particles are real, in the sense that their existence is independent of our experimentation and observation; but, a description of their momenta and positions depend upon our interactions with the particles, our observations, in experimental situations. Similarly, works of art hang around without people, but their function as works of art is in an idle state without the observations and doings of artists and audiences. The musician playing alone may be practising or rehearsing, but is not performing. Works of art are functionally nothing without performance. Performance is nothing without an audience. In other words, we have the artist-audience relationship, the artist-work of art relationship, and the work of art-audience relationship, and those relationships constitute the arts. When any of them are severed we have no arts except as the arts in an idle state; similar to cars sitting in a parking lot doing nothing.

If humanity walked off the stage of the universe, the universe would go on unobserved. Whereas, works of art without humans around, do not have a function; nor an existence as art, but only an existence as physical objects: as scripts for unperformed plays, or books as texts without readers, or paintings as blobs of colour on canvass hanging on the walls of empty houses, empty art galleries, empty art museums. Another way of putting the point about works art as intimately bound up with humanity, our biology, our emotions, our cultures, goes as follows: the observation of works of art is part of the art culture as well as the creation of works art. Both observing and creating works of art are aspects of the culture of art. This was a point made by Robin George Collingwood:

> The audience is perpetually present to him [the artist] as a factor in his artistic labour; not as an anti-aesthetic factor, corrupting the sincerity of his work by considerations of reputation and reward, but as an aesthetic factor, defining what the problem is which as an artist he is trying to solve – what emotions he is to express – and what constitutes a solution of it. The audience which the artist thus feels as collaborating with himself may be a large one or a small one, but it is never absent.[11]

A consequence of this discovery by Robin George Collingwood is the fundamental problem of the arts that I raised at the very beginning of this section: if the observer is part of the creation of the work of art – reproductions, performances, commentaries, and so on and so on – how do we get back to the work of art itself? How do we demarcate and define the work of art without all the accretions of its history of observation and commentary? More

[11]COLLINGWOOD, Robin George. **The Principles of Art**, Oxford: Clarendon, 1938; pp. 315.

importantly, how do we experience the work of art without the intermediaries of its critics and connoisseurs?

Let us return to the thought-experiment of a Martian visitor. The Martian visitor can get at the work of art itself. He can see the object without its historical and cultural accretions. The work of art for him is nothing more than any other object, with its own laws of behaviour; its own science. However, for we mere mortals on the stage of life, the work of art is on the stage with us. We are in continual transaction with the work. It is not static. We try to grab it and isolate it and experience it in a manner pure and simple, and we cannot. We come to La Gioconda humming the tune of "Mona Lisa, Mona Lisa", or with Marcel Duchamp's moustache, or with a reproduction on a tee-shirt, or with a memory of Sigmund Freud's writing on da Vinci[12] and Freud's critics[13] and so on. However, the Martian may know all this, but it does nothing to its emotional response, for the Martian has no emotional response. The Martian is not really part of the human audience who observes the work of art. The Martian can be polite and clap when everyone else claps, or laugh when everyone else laughs, or repeat the joke, but he cannot get it, no matter what. The Martian can get everything about the arts except its relationship with humans and our humanity.

The fundamental problem of the arts cannot be resolved. We cannot observe the work of art free from the play of our imaginations, interpretations, cultural background, or our obsessions and neuroses – our humanity. In the words of Robin George Collingwood:

> This activity [the aesthetic activity] is a corporate activity belonging not to any one human being but to a community. It is performed not only by the man whom we individualistically call the artist, but partly by all the other artists of whom we speak as 'influencing' him, where we really mean collaborating with him. It is performed not only by this corporate body of artists, but (in the case of the arts of performance) by executants, who are not merely acting under the artist's orders, but are collaborating with him to produce the finished work. And even now the activity of artistic creation is not complete; for that, there must be an audience, whose function is therefore not a merely receptive one, but collaborative too. The artist (although under the spell of individualistic prejudices he may try to deny it) stands thus in collaborative relations with an entire community; not an ideal community of all human beings as such, but the actual community of fellow artists from whom he borrows, executants whom he employs, and audience to whom he speaks. By recognizing these relations and counting upon them

[12]FREUD, Sigmund. **Leonardo da Vinci and a memory of his childhood**. New York: Norton, 1964.
[13]SCHAPIRO, Meyer. "Leonardo and Freud: an art-historical study", **Journal of the History of Ideas**, vol 17, No.2, Apr. 1956; pp. 147-178.

> in his work, he strengthens and enriches that work itself; by denying them he impoverishes it.[14]

The arts allow us to deploy our humanity. The observation of works of art is similar to the experience of jokes. We can explain jokes, psychoanalyze jokes, and develop theories of the history, sociology, and criticism of jokes. But getting the joke and experiencing the work of art is another matter. We need to engage in jokes and works of art with our whole being or to exercise our humanity in its full scope in order to get them: our jokes and works of art.

The arts and physics are humanistic social endeavours where the observer cannot but help shape their own observations in the questions they, we, ask. The questions we ask frame the answers; and observers need to ask questions in order to observe, even if only in the form of unconscious expectations.

III. Does observing in the sciences and in the arts take place in very different ways?

You might wonder whether I have over-emphasized the commonalities between observing in the sciences or physics and in the arts. You might point out that observing in physics both involves and requires a certain objectivity that cannot be required in the arts. One needs to come to an agreement about the importance and relevance of the observations with other observers when running an experiment. One needs to discuss with others whether data has been found that supports or not a theory or conjecture that is being put to the test. Does the observation cause trouble for a theory? Is the observation relevant and supportive or not for a framework, or network of theories under development? Is the observation ground-braking for an important practical application? For instance, let me remind you of the fuss about cold fusion some years ago, and actually still going on, not as hot as it was in its early days, but at least lukewarm[15].

The story of cold fusion began with the news reports of the observation of an experiment to create nuclear fusion using a device at a low temperature. However, many attempts failed to reproduce the observations of cold fusion (nuclear fusion at low temperature that releases nuclear energy on the cheap, or more heat than was put in to create the nuclear blast) as initially reported[16]. Hence, objectively observing cold fusion did not

[14]COLLINGWOOD, Robin George. **The Principles of Art**, Oxford: Clarendon, 1938; pp. 324.
[15]https://medium.com/eranova-institute/cold-fusion-is-hot-again-again-11-years-after-cbs-news-first-said-it-was-69e2f12edfa1 accessed May 6, 2021.
[16]FLEISCHMANN, M., PONS, S., HAWKINGS, M., **J. Electroanal. Chem**. 261, 310, 1989 and **J. Electroanal. Chem**. 263, 187, 1989.

happen and "notable exceptions" to the failed observations of cold fusion "may be due to the Bose-Einstein condensation of deuterons"[17].

Observing in the arts is not objective to the same degree as in the sciences. Observing a painting is not completely subjective in that what one sees in the painting, a woman smiling, or a mountain in the distance, or stars in the night, can be seen by many others. But in the seeing, the response is different from the seeing in the experiment: the clinical observation in a laboratory, using very complex and highly technical equipment for testing the theory (of how to make nuclear fusion occur at room temperature, so-called "cold fusion"). I do admit that this difference in observing the sciences and the arts is fundamental: for the sciences we want objective observations or observations that can be exactly reproduced for different scientists, even when using the same recipe, the experimental equipment made to the same specifications. But the difference does underline the human element in both the sciences and the arts. Without other scientists attempting to reproduce the experimental situation that created the observation used to test a theory, the theory is pointless. Similarly, without people observing a work of art, or without an art-audience, the work of art is also pointless.

John Archibald Wheeler has an interesting way of putting what I am saying. In another interview, he proposes that though the sciences and the arts both rely on participation through observing, the arts unlike the sciences, require a deep personal and emotional involvement in observing the work of art:

> I remember so well the words of one artist who was kind enough to give me art lessons in Paris in 1949. I went twice a week to him for drawing. He told me how he had got his education at the Ecole des Beaux Arts in Paris. He said that his fellow students there were so well trained in observing things carefully and accurately, to get the truth, that they understood him better than his own father and mother understood him. This made a great impression on me – this concern for accuracy and truth.
> But to me also it was very interesting the idea that in art you are trying to distill out of the situation some central thing and find out what that central thing really is and capture it in its naked essence, free of all complications. And that to me is what is so impressive in science. There, too, we are trying to do this all the time: capture the naked essence of the situation in the very simplest terms. So, to me there is a very great similarity between the two: the search for truth and the search for the absolutely central point.
> But certainly there is also a difference. A work of art only really comes alive if it produces some resonance in the hearts of the people that look at it.

[17]KIM, Yeong E. and ZUBAREV, Alexander L.. "Ultra Low-Energy Nuclear Fusion of Bose Nuclei in Nano-Scale Ion Traps". In: SCARAMUSSI, F. (ed.). **Conference Proceedings**, Vol. 70, "ICCF8", SIF, Bologna, 2000; pp. 375-384.

> Something may be a wonderful work of art but if the people are wrong people to look at it, it has no effect. It is tied, therefore, to the human heart in a way much closer than science is. It is true that science is a human activity, and it is a collaborative activity, and it is true that if someone does a piece of work and nobody pays attention to it, then it has no effect. But in the case of science you could say that there is a kind of democracy about it. The steps in a proof are democratically open for everybody, or for every qualified person, to check for himself. Or an experiment is democratically open for anybody to check for himself if only he knows how to do experiments. In the case of art, well, I suppose, one would say there, too, that it is democratically open to anybody to resonate to it but it does not have the same compulsion about it. In the case of the proof – there is the proof, in the case of the experiment – there is the experiment. You will come out with "yes" or "no" at the end of it. But in the case of the work of art it is not "yes" or "no", it is resonance.[18]

No people, no arts, no sciences. But observing is not neutral: both in the arts and the sciences, questions and responses set the frame and purpose for observing. As I discussed earlier: both in the sciences and in the arts, observing can not get us to the hard core of reality, free of questions and theory; nor to the work of art unencumbered by historical and critical discussion. Every once in a while, scientists observing an experimental test, turn a theory upside down, in an unexpected way. For instance, the famed Michelson-Morley experiment unexpectedly failed to detect the ether. However, "...the role of the Michelson experiment in the genesis of Einstein's theory appears to have been so small and indirect that one may speculate that it would have made no difference to Einstein's work if the experiment had never been made at all"[19]. Though we may not know how Albert Einstein came to think up the special theory of relativity, Albert Einstein's special theory of relativity theory shook the world in 1905. Similarly, Impressionist Art shook the art world, in 1875. Art-audiences observing the latest exhibition, join in turning the art world inside out as in the first exhibit of Impressionist art satirized by Louis Leroy on April 25, 1875 in *Le Charivari*[20]. Indeed, the failed observations, failed experiments, and the new theories in the sciences; and, the shock of the unexpected for audiences observing new works of art, reveal the importance of tradition and social worlds or cultures for humanity.

The shock of the new and the unexpected when tradition fails us, underscores how our humanity shapes us and how we shape our humanity.

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[18]WHEELER, John Archibald and BICAK, Jiri. "The art of science: interview with Professor John Archibald Wheeler, May 29, 2018". **General Relativity and Gravitation,** 41, 2009; pp. 679-689.
[19]HOLTON, Gerald. "Einstein, Michelson, and the "Crucial" Experiment". **Isis**, Summer, Vol. 60, No. 2, 1969; pp. 132-197.
[20]REWALD, John. **The History of Impressionism**. New York: The Museum of Modern Art, 1973; pp. 323. Available in: http://www.artchive.com/galleries/1874/74leroy.htm. Accessed on May 6, 2021.

The force of the satirical critique of Impressionism had an opposite and equal reaction, in catapulting Impressionist artists into the limelight. Moreover, there was a secondary reaction against tradition in criticism, in the social world and institutions of art, in schools and museums. The counter-styles, counter-schools, and counter museums of the avante-garde developed as a reaction against tradition. What happened was that once tradition became an anchor as opposed to a rudder, there was no choice for artists who sought to experiment, who sought for novelty, who sought for a fresh way for doing art. The whole social world of art including the styles of art, and the critical discussion of art, without tradition as a rudder, went in all directions and became subject to the bandwagon effect of fashion[21].

Basically, when the rudder of tradition is either turned into an anchor, or is dismantled, in our institutions of the social world of the arts, those artists looking for a fashion, or the latest bandwagon, can turn to critics as their guides, and to paraphrase the culture critic, Tom Wolf (1930-2018), paint their words[22]. Tradition, on one side, can act as a frame for creating and observing in the arts – for providing a direction to those artists who both seek to create novelty and those who seek to act as participant-observers in the social world of art[23]. The irony is that though tradition, on the other side, can act as an anchor, without tradition we have no framework for an audience and for critics to recognize novelty, and to become fully involved as participant-observers as appreciative audiences.

Karl Popper has an interesting take on what I see as the rudder role of tradition: “traditions have the important double function of not only creating a certain order or something like a social structure, but also giving us something upon which we can operate; something that we can criticize and change”. And, “Towards a rational theory of tradition”[24].

Humans unlike imaginary Martians and the supposed future development of artificially intelligent machines such as AGI systems, live in history. We remind ourselves about our past, and develop expectations, guesses, and thoughts about the future within the framework of history and tradition. There is no tradition, and no social world for computers, even if computers supposedly think and learn.

[21]GOMBRICH, E. H. “The Logic of Vanity Fair: Alternatives to historicism in the study of fashions, styles and taste”. In: SCHILPP, Paul Arthur (ed.). **The philosophy of Karl Popper**. La Salle Illinois: Open Court, 1974; pp 925-957.
[22]WOLF, Tom. **The painted word**. New York: Picador/Farrar, Straus & Giroux, [1975] 2008.
[23]RICHMOND, Sheldon, JARVIE, Ian and AGASSI, Joseph. “Ernst Gombrich, Karl Popper und die Kunsttheorie”. FRANCO, Giuseppe (ed). **Handbuch Karl Popper**. Wiesbaden: Springer VS, 2019; pp. 667-678; and AGASSI, Joseph JARVIE, Ian. **A critical rationalist aesthetics**, Amsterdam: Rodopi, 2008.
[24]POPPER, Karl. **Conjectures and refutations: The Growth of Scientific Knowledge**. New York and London: Basic Books, 1962; pp. 131 and 120-135.

Observing in the sciences and in the arts relies on traditions within our various social worlds. Observing in the arts and in the sciences is embedded within our traditions in social worlds; and as such, embedded in questions. The answers of the arts resonate with the participant-observer, sometimes in harmony, or sometimes out of tune, and sometimes with a mixture of the harmonious and a-harmonious; whereas, the answers to the questions of the observer-participant in QM are a clear cut, yes or no.