Extending Wheeler's Participatory Universe:

Conceptual Framework for a *'Measureverse'*

Gregory O'Grady*

Abstract

In his 'Participatory Universe', John Archibald Wheeler envisioned the universe as a kind of 'self-excited circuit', in which acts of observation on the earliest universe have "*a part in bringing that universe into being".* This paper proposes that several anomalies in the cosmic microwave background (CMB) may be explainable within a Participatory model. Specifically, peculiar alignments between the CMB and our own solar system appear, if confirmed, to challenge the Copernican Principle, while raising a temporal paradox given the vast interval between CMB photon decoupling and the present observer. It is proposed that this paradox could be mitigated if detector-based measurement itself 'participates' in the release histories of registered CMB photons. A strict Bohr and Wheeler-inspired notion of measurement as 'irreversible amplification' is employed, treated as distinct from environmental decoherence. Through this approach, the measured CMB is posited not as a static fossil background, but instead as a 'reference frame' always relative to an observer, which becomes skewed to their state and motion. It is explained how this Participatory frameshift could offer a unified means of approaching multiple measured cosmological tensions, including alignment anomalies, the low-power anomaly on the largest angular scales, and discrepancies between CMB and matter-based dipoles. The paper first reviews Wheeler's Participatory model, before exploring broad conceptual implications encompassing the initial conditions of the universe, CMB anomalies, the genesis of physical reality, and the role of measurement itself, motivating a new overarching conceptual framework labelled the 'Measureverse'. The proposal is exploratory, being intended to stimulate interdisciplinary dialogue.

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* Prof. Gregory O'Grady, The University of Auckland, New Zealand; email: greg.ogrady@auckland.ac.nz

Introduction

Intractable problems in the foundations of physics continue to defy conventional approaches to yield a coherent picture of the universe. One deep, unsettled problem concerns the mechanisms by which physical reality is synthesized from a basis of elementary quantum phenomena. This challenge manifests critically at two frontiers. First, at the laboratory scale, concerning how quantum descriptions can be reconciled with classical behavior; a dilemma encapsulated by the measurement problem. Second, at the cosmic scale, concerning how primordial quantum fluctuations were actualized to seed the specific large-scale structures of the universe.(1) While the prevailing inflationary paradigm provides a mechanism for generating these structures, open theoretical questions and persistent anomalies in the cosmic microwave background (CMB) indicate that our understanding of these events remains incomplete. There is currently no consensus solution that conceptually links these scales.

One unexpected approach to such problems is the ‘Participatory Universe’ proposed by John Archibald Wheeler (1911-2008). Wheeler formulated this model in his later years, following diverse experiences in the foundries of quantum physics, particle physics, and general relativity, which led him to reflect deeply upon the nature of physical reality and its relationship to quantum measurement.(2) Wheeler’s model was grounded in a prodigious theoretical depth, but propelled by a principle he termed ‘radical conservatism’. Thorne explains the approach: “Base your research on well-established physical laws (be conservative), but push them into the most extreme conceivable domains (be radical)”.(3) Wheeler’s driving motif was that “*In some strange sense, the quantum principle tells us that we are dealing with a participatory universe*”, which he applied universally.(4)

The overall reaction from the scientific community to Wheeler’s approach has been respectfully muted, with its application being primarily philosophical. However, definitive verifications of his delayed-choice experiments,(5,6) as well as Nobel recognition for experimental work verifying the principles of quantum non-locality, provide impetus to re-evaluate Wheeler’s approach to form a universal model of reality from quantum fundamentals. Yet Wheeler’s model was formative, incomplete, counter-intuitive, and not always accessible, often being expressed within probing philosophical enquiries and cryptic ‘apt slogans’, which has often contributed to it being misunderstood or overlooked.

A further issue that may have contributed to Wheeler's approach being overlooked was his atypical mode of enquiry.(7-11) In addition to radical conservatism, Wheeler applied other advanced philosophical ideation techniques, including:

- *Redefinition*: deliberately reinterpreting and bypassing prevailing concepts to derive radically new perspectives that might otherwise pass unconsidered.
- *Abstraction*: identifying key principles while abstracting away details and mathematics, to yield generalized frameworks that could unify seemingly unrelated problems.
- *Visual thinking*: employing symbolic diagrams to conceptualize and convey complex ideas.
- *Conceptual priority*: prioritizing intuition and establishing logic prior to formalization.

This combination of techniques, which Wheeler exemplified throughout his career, offers a powerful mode of inquiry to break established thinking patterns, inspire original thought, and reframe intractable problems in search of original solutions.(2)

This paper is motivated by the view that a critically important role for a Participatory model is being overlooked in the foundations of physics. The paper therefore presents a series of hypotheses that revisiting this model may have potential to advance several current challenges, particularly the growing tensions in the standard cosmological model, while remaining compatible with prevailing theories due to complementarity.(12) A brief synopsis of the Participatory model is provided first, bridging diffuse sources including Wheeler's published narratives, interviews, and unpublished journals.(10) The model is then extended by employing Wheeler's own distinctive ideation techniques to reframe selected problems through a method designated here as '*Participatory redefinition'*. Hypotheses introduced and assessed using this approach include the nature of measurements performed on the cosmic microwave background (CMB) and its power, alignment, and kinematic anomalies, the ontological status of the initial conditions of the universe within a participatory model, and the generation of a shared classical reality from a common quantum substrate. Through provocative and highly abstracted modes of enquiry and 'visual thinking diagrams', the overall conjecture is posed that a shift in perspective offered by a Participatory framework might open new avenues of thought to usefully evaluate currently intractable problems.

Principles of the Participatory Model

Wheeler's participatory Universe emerged from the Copenhagen Interpretation of quantum mechanics. Following his mentor Bohr, he viewed the collapse of the quantum wavefunction as the fundamental event comprising reality, stating "*No elementary phenomenon is a phenomenon until it is a registered phenomenon… brought to a close by an irreversible act of amplification*."(13,14) A measurement was framed as "*anything that can preserve a record*", which could be "*a person or a device or a piece of mica*".(2) He used the term 'observer' in a minimal sense (retained hereafter), as any physical system capable of retaining this irreversible record of an interaction. Although Wheeler was also instrumental in formalizing Hugh Everett's many-worlds interpretation, he did not embrace it, stating "*If there's anything designed to confuse somebody about what quantum mechanics is all about, this does it*".(15)

Wheeler's conviction in the quantum principle solidified after a crisis of confidence in the fundamentality of general relativity, arising from his work on gravitational collapse and black holes.(4,16). He came to present a quantum-first model as diametrically opposed to that of his colleague Einstein, whose realist position was that the "*belief in an external world independent of the perceiving subject is the basis of all natural science*"(17); Wheeler responded: *"[This] states the opposite of the view that I want to spell out in enough detail to make it plausible and testable*".(10) His strategy was to openly build an integrative theory for conceptual exploration and explanatory synthesis. He stated: *"It's not just a matter of nice simple formulas, there are some ideas out there that are waiting to be discovered*",(15) and he relayed these ideas in essays, drawings, paradoxes, and riddles, some simply intended to 'inspire thought', while searching for firmer foundations to reduce concepts to experiments, and experiments to evidence.

These inquiries led Wheeler to devise his eponymous delayed-choice experiments between 1978 and 1984.(6,18) His motivation was to test whether nature behaves in accordance with the predictions of quantum mechanics, specifically with regard to the role of measurement and temporal non-locality.(18) Building on Young's double-slit experiment, he devised thought experiments in which an observer's choice of what to measure could be regarded as influencing the past history of the measured system. His thought experiments were experimentally verified by Alley et al and others,(6) before being realized in a manner close to Wheeler's original conception in 2007.(5) Wheeler concluded: "*In the delayed-choice* *experiment we, by a decision in the 'here and now', have an irretrievable influence on what we will want to say about the past - a strange inversion of the normal order of time. This strangeness reminds us more explicitly than ever that the past has no existence except as it is recorded in the present.*"(15)

Propelled by radical conservatism, Wheeler next extended delayed-choice to cosmic scales, noting "*if it is true in a laboratory, it is surely real in a baseball diamond and in the universe at large*"(2). He thus conceived a galactic variant of delayed-choice that would "*determine which path was followed a billion or so years after the photon started its journey.*"(18) (**Figure 1)**. Steps were taken toward testing this idea in 2017, extending delayed choice to thousands of kilometers using satellite links.(19) While not yet at the galactic scale, the authors concluded "*we can confute with clear statistical evidence of 5σ the description of light quanta as classical particles*".

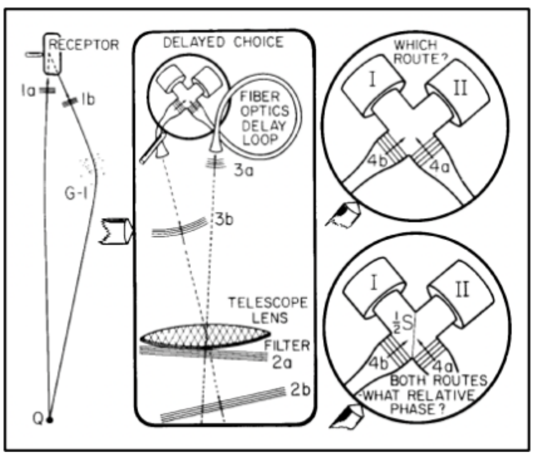


Figure 1. *Wheeler's cosmic-scale delayed choice gedankenexperiment: Left: Due to the gravitational lens action of galaxy G-1, light generated from quasar (Q) has two possible paths to reach the receptor. Center: Filters are used to increase the coherence length of the light, thus allowing the interference experiment. A fiberoptics delay loop adjusts the phase of the interferometer. Right: The choice not to insert (top) or insert (bottom) the half-silvered mirror at the final stage of the experiment allows one to either measure which particular route the light traveled or what the relative phase of the two routes was when it traveled both of them. Given the distance between the quasar and the receptor (billions of light years), the choice can be made long after the light's entry into the interferometer, an extreme example of the delayed choice gedankenexperiment. Figure and caption adapted from Wheeler; Ref (18).*

Verification of delayed choice provided empirical support for temporal non-locality as a fundamental property of the universe, and for the role of measurement in actualizing reality. These concepts grounded Wheeler's general Participatory model, in which he proposed that all of reality rests on a compilation of measurements, accumulated over time. Present reality is then continuously rendered by new measurements, which Wheeler framed as '*acts of participation'* (**Figure 2**).(2)

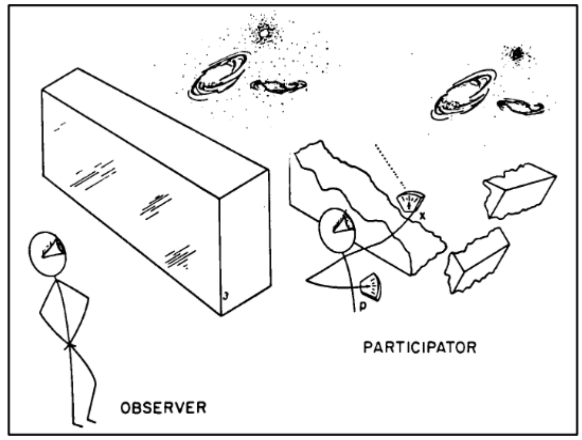


Figure 2. *Wheeler's sketch of the participatory principle: "The left-hand view symbolizes the concept of the universe of the old physics. Galaxies, stars, planets, and everything that takes place can be looked at, as it were, from behind the safety of a one-foot-thick slab of plate glass without ourselves getting involved. The right-hand view reminds us that the truth is quite different. Even when we want to observe, not a galaxy, not a star, but something so miniscule as an electron, we have in effect to smash the glass so as to reach in and install measuring equipment…. Moreover the act of measurement has an inescapable effect on the future of the electron. The observer finds himself willy-nilly a participator. In some strange sense this is a participatory universe." (9).*

To reconcile how a coherent reality could be assembled from a patchwork of participatory measurements, Wheeler posited a solution within information theory, introducing a fundamental unit of reality which he termed '*it from bit*'.(8) He theorized that "*every it - every particle, every field of force, even the space-time continuum itself - derives its function, its meaning, its very existence entirely - even if in some contexts indirectly - from the apparatus elicited answers to yes-or-no questions*".(8) His model of reality thus had two complementary components: first, a threaded history of 'registered facts' that he called '*iron rods of observation'(14);* and second, the remainder of the universe lying in states of quantum superposition, which he described as '*great clouds of probability'.(2)* Wheeler symbolized this relationship as shown in **Figure 3**, comparing his model to that of the atom, noting "*Rutherford and Bohr made a table no less solid when they told us it was 99.9 percent emptiness*".(8) Critically, causality was preserved because the "iron rods" of reality obey classical principles, while all newly registered (measured) phenomena joined reality with a congruence dictated by quantum probabilities.(9)

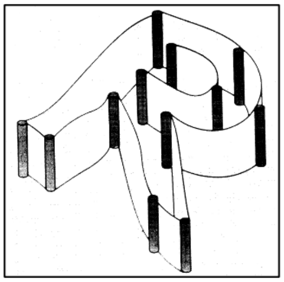
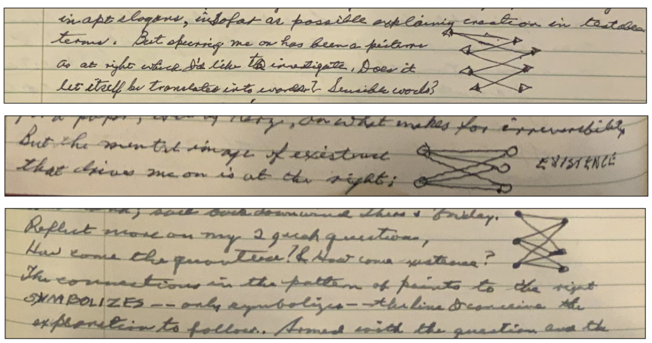


Figure 3. *Wheeler's symbolic representation of reality; a visual thinking model. Reality comprises two components: first, a framework of "registered phenomena", representing "iron rods" of reality developed through previously-registered acts of measurement; and second, a "papier-mâché construction" of "great clouds of probability running around the universe that have yet to trigger some registered event in the macroscopic world".(2,9)*

In his later journals, Wheeler extended this conception of reality toward a shared framework among mutual observers to be derived by interconnected self-organizing measurement webs. He symbolized this idea with a further visual-thinking model of interconnected nodes, invoking "*the mental image of matchsticks found on floor, picking selves up*" (Figure 4).(10)



"…in apt slogans, insofar as possible explaining creation in testable terms. But spurring me on has been a picture as at right which I'd like to investigate. Does it let itself be translated into words? Sensible words?"

"But the mental image of existence that drives me on Is to the right;"

"Reflect more on my 2 great questions, How come the quantum? How come existence? The connections in the pattern of points to the right SYMBOLIZES - - only symbolizes - - the line I conceive the explanation to follow.

Figure 4*. 'Visual thinking' models of reality as an interconnected web of measurement nodes; John Wheeler c.1995.(10) With thanks to the American Philosophical Society, John Archibald Wheeler Papers.*

Wheeler's Participatory model reached its conceptual peak under radical conservatism and redefinition when applied to the origins of the universe itself. Extrapolating radically from delayed-choice, he proposed that acts of observation on the earliest universe must also be fundamentally participatory, stating: "*We ourselves get radiation today from the very early days of the universe… [so] we can say, this observer who was brought into existence by the universe, has, by [their] acts of observation, a part in bringing that universe itself into being."(15)* He likened this relationship to a '*self-excited circuit'*,(9) which he illustrated using a diagram of the universe in the shape of a 'U', in a manner "*meant to inspire thought* "(**Figure 5**).

Figure 5. *Iconic visual thinking diagrams of John Wheeler.* **Top Left**: Wheeler's *U (2): "It's a picture to inspire thought... There's the letter 'U'. The U starts with a thin stem, the beginning of the universe. At the beginning, the universe is small. This stemmed U gets fatter as we go up to this side of the letter. And at a certain point it's terminated by a big circle, and there, there's an eye sitting and that eye is looking back to the first days of the universe".(15) The image is symbolic; with the eye denoting 'anything capable of preserving a record'.(2)* **Centre**: Referencing Bohr, Wheeler writes "*The elementary quantum phenomenon is a great smoky dragon. The mouth of the dragon is sharp where it bites the counter. The tail of the dragon is sharp where the photon enters. But about what the dragon does or looks like in between we have no right to speak, either in this or in any delayed-choice experiment."(13)* ***Right and Below****: Examples of U 'visual thinking' sketches that Wheeler made repeatedly in his journals, a practice he continued until his death aged 96. At top right, an example is included where the U symbol is united with the 'smoky dragon' symbol. At bottom, an example is shown next to the phrase 'Everything from Nothing'.(10) With thanks to the American Philosophical Society, John Archibald Wheeler Papers.*

Wheeler's extension of participatory principles to the origins of the universe, which most considered too radical, alienated many physicists who resisted challenges to realism; while others discounted his approach as mystical or invoking an improbable role for consciousness in the early universe.(2) Wheeler resisted these criticisms as merely radically conservative, and observed: "*In these later years, I have dared to think about and write about and ask about the physical world in terms that some of my colleagues consider outside the scope of science.*"(2) In his defense, Feynman commented: "*This guy sounds crazy… But when I was his student, I discovered that if you take one of his crazy ideas and you unwrap the layers of craziness one after another like lifting the layers off an onion, at the heart of the idea you will often find a powerful kernel of truth."(3)*

In summary, Wheeler's Participatory model presented a scientifically-consistent redefinition of physical reality based on the fundamentality of his 'quantum principle', which was diametrically opposite to the prevailing realism championed by Einstein. According to Wheeler's model, reality is a consequence of interdependent measurements, made whole through complementarity, information theory, quantum probabilities and self-organization.(8) Indeed, Wheeler argued this was the '*only'* logical conclusion that could be arrived at, stating "*But is there any other reality in the world except what we get by these acts of registration? If not, then how could one expect to build a theory of the world on anything but acts of observation? That is where, I think, one has a doorway to the future*".(15)

Extending the Participatory Universe

Having briefly surveyed Wheeler's model, this paper now extends and applies Participatory principles to hypothesize new avenues of enquiry to selected problems in the foundations of physics. Wheeler's ideation techniques of radical conservatism, redefinition, abstraction, and visual thinking are applied to propose '*Participatory redefinitions',* defined here as the reframing of current problems to place the quantum principle centrally in an attempt to break established patterns of thought. The overall hypothesis is that Participatory perspectives may offer a missing link that could unify intractable problems under a common framework, while remaining compatible with prevailing theories due to complementarity. Possibilities to reconcile these conjectures with unexplained cosmological observations are discussed.

Hypothesis A*: Measurements of the Cosmic Microwave Background (CMB)*

The CMB represents the oldest observable window into cosmic origins, being radiation released at the era of recombination, and providing fundamental data on the structure and evolution of the universe.(1) Increasingly precise measurements over the COBE, WMAP and Planck missions have generally supported the ΛCDM Standard Cosmological Model, however, several persistent unexplained anomalies pose residual challenges. The first proposed *Participatory redefinition* focuses on the nature of CMB measurements.

When considering the interaction between a detector and CMB photons, two conceptions are possible. The first conception is that the CMB detector passes through a fog of classically-propagating photons in space, passively collecting them within its apparatus (**Figure 6; left**). While this 'classical fog' serves as a convenient heuristic in standard cosmological practice, it is in contrast to the strict quantum description wherein photons propagate as probability waves, rather than defined trajectories, until registered, as exemplified in delayed-choice experiments in space.(19) Consequently, an alternative Participatory conception can be presented, inspired by Wheeler's model, whereby CMB photons remain in a state of quantum superposition up until their moment of final measurement by a participating detector (**Figure 6; right**). This conception also implies, per Wheeler's gedankenexperiments, that the emission and propagation histories (hereafter 'release histories') of the registered CMB photons remain undefined until their moment of measurement, regardless of this being ~13.8 *"billion or so years after the photon started its journey"*.(2)

A critical distinction is drawn here between decoherence and Wheelerian 'measurement'. In standard cosmology, CMB anisotropies are treated as effectively classical, with early environmental decoherence at the epoch of recombination taken to have rendered interference between alternative histories practically negligible and to have stored redundant information about them in environmental degrees of freedom. The present Participatory model accepts the dynamics of decoherence but denies that it, by itself, constitutes 'measurement' in Wheeler's sense. Instead, such interactions are treated as part of an undefined 'cloud of probability' (the body of Wheeler's 'smoky dragon') until the chain of causality is ultimately and definitively terminated by a 'measurement', defined as an irreversible act of amplification that produces a stable macroscopic record in the present. Per this stricter Wheelerian interpretation, intermediate interactions, even when they generate environmental records in the decoherence-theoretic sense, do not by themselves count as measurements that contribute to 'reality'

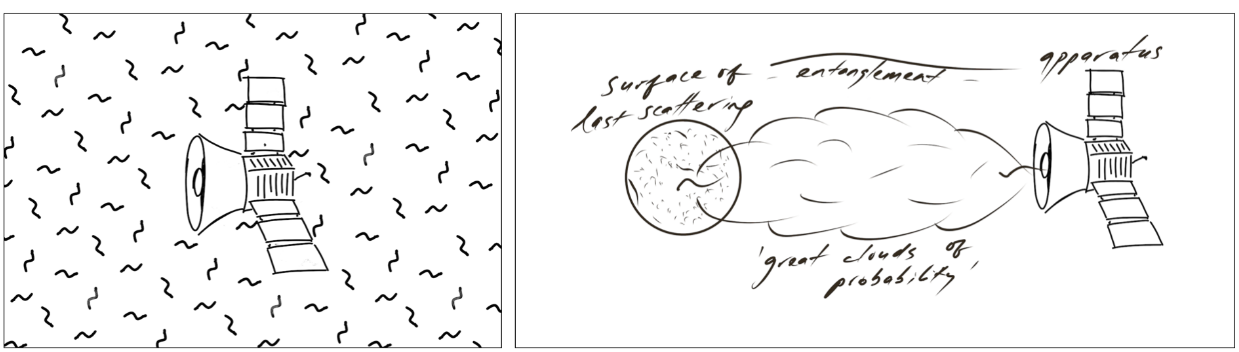


Figure 6. *Visual thinking diagram contrasting a simplified classical picture with a participatory quantum interpretation of CMB measurements.* ***Left****: Intuitive classical conception of a CMB detector passing through a fog of classically-propagating photons filling space (per Wheeler: "the concept of the universe of the old physics".(14))* ***Right:*** *Participatory redefinition of a CMB detector.*

Wheeler's vision was that CMB photons remain in a state of quantum superposition until finally measured, which induces wavefunction collapse at registration of a particle at the detector. This measurement is thus regarded as 'actualizing' the emission and propagation history of the registered photon into reality.(13)

Applying principles derived from delayed-choice and its implications for temporal non-locality, CMB radiation from the last scattering surface may therefore be simultaneously conceived under this second framework as both a 'fossil relic' of the early universe and a participant in measurements made *'here and now*'. This temporal paradox may be reconciled by recalling Wheeler's U-diagram and his conclusion from delayed-choice that "*the past has no existence except as it is recorded in the present*".(15)

The implications of this model for the initial conditions of the universe are discussed next, establishing the necessary context to subsequently address several specific anomalies observed in CMB measurements.

***Hypothesis B**: The Initial Conditions of the Universe*

The prevailing conception of the Big Bang is expressed in popular simple visual-thinking form per **Figure 7A**. This model has extensive explanatory power, is substantiated by abundant empirical evidence, and is widely accepted.(20) However, the theory is also fundamentally incomplete due to residual challenges, particularly regarding its initial conditions. Dominant versions of the theory contend that the universe began with an inflationary event, expanding by a factor of $>10^{25}$ within $\sim10^{-30}$ of a second, yielding the conditions of the hot Big Bang including a flat, isotropic, homogeneous universe.(21) However, events can only be securely extrapolated back to the end of the inflationary era, and while numerous inflationary models have been proposed, there is no consensus on a satisfactory mechanism for inflation and its graceful exit.(22) It is also considered that primordial quantum fluctuations in an inflaton field were imprinted into the inflating universe, via the acoustic oscillations in the photon-baryon plasma, seeding large-scale structures as observed in the fluctuations of the CMB. Yet the mechanisms of such concepts also remain unresolved, with problems including how inflation starts and ends, and implications for eternal inflation, including an enormous, possibly infinite, ensemble of non-uniform regions in space.(22)

Wheeler viewed these problems as specific targets for *Participatory redefinition*, as they lie at the intersection of quantum principles and physical reality. A participatory approach to the universe's earliest conditions may therefore be initiated that extends Wheeler's model, starting with the visual-thinking diagram in **Figure 7B**.

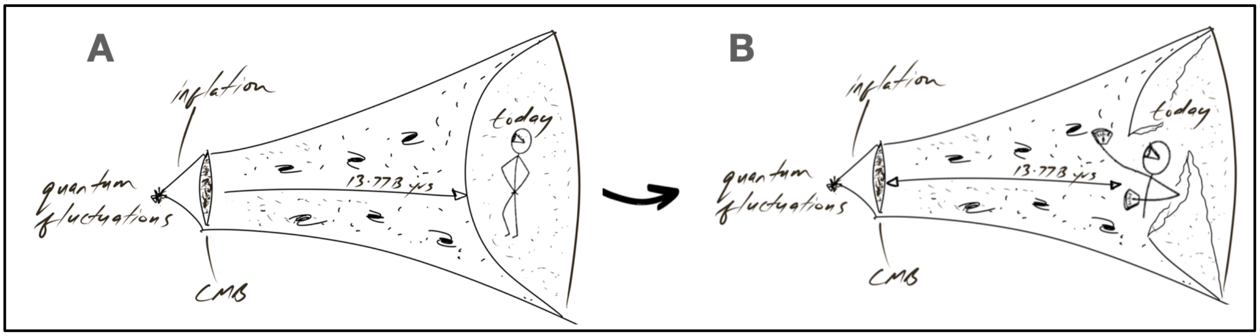


Figure 7. *Visual thinking diagrams of observing the universe's history.* ***A****: Prevailing conception; the universe is currently viewed, per Wheeler, "from behind the safety of a one-foot-thick slab of plate glass without ourselves getting involved".* ***B****. Participatory redefinition: "the truth is quite different... Even when we want to observe... we have in effect to smash the glass so as to reach in and install measuring equipment… The observer finds himself willy-nilly a participator." Figure contents adapted from* ***Figure 2*** *(9).*

A *Participatory redefinition* hypothesis of the universe's initial conditions is thus advanced in three steps that explicitly reframe Wheeler's "self-excited circuit":

- **Figure 8A**. Per the Participatory model, we restate visually the principle that every phenomenon in reality is generated by an 'it-from-bit' measurement registered upon a substrate quantum field.
- **Figure 8B.** Under radical conservatism, the same conception is extended to *any* measurement of radiation performed on the universe's past. Again, in contrast to standard cosmology identifying early environment decoherence with measurement, Wheeler's stricter requirement is instead applied that only 'irreversible registration' counts (refer Hypothesis A). (15) This reflects delayed-choice and **Figure 6**, recalling that in Wheeler's model, measurements made in the *"here and now*" can be said to have actualized photon release in the past in "*a strange inversion of the natural order of time"*.(15)
- **Figure 8C**. A boundary is reached (i.e. a participatory boundary condition is established) when measuring radiation at the earliest observable window of the universe (CMB). At this boundary, per Wheeler, the total sum of CMB photons measured by any detector can be stated to have been actualized from measurements performed upon a primordial substrate quantum field in the *'here and now*'. This conceptualization follows Wheeler's 'U with smoky dragon' (**Fig. 5**), and his comment:

"[so] we can say, this observer who was brought into existence by the universe, has, by [their] acts of observation, a part in bringing that universe itself into being"(15).

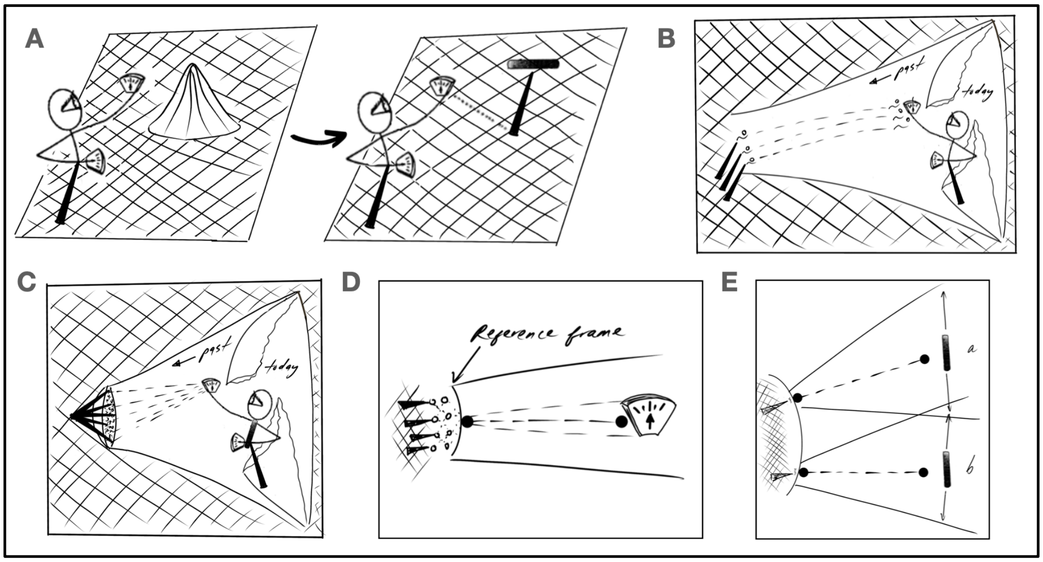


Figure 8. *Visual thinking diagrams of 'Participatory redefinition' applied to the universe's initial conditions.* ***A****. Per Bohr, "no elementary phenomenon is a phenomenon until it is a registered phenomenon."; symbolized here as an it-from-bit measurement upon a substrate quantum field, generating an 'iron rod of reality'.(14)* ***B****. As informed from delayed-choice principles, this concept applies without exception to any measurement performed on the universe's past.* ***C.*** *At the earliest universe, a boundary is reached. Under a participatory model, measurements from within the universe itself induce wavefunction collapse at the primordial substrate quantum field, generating the release histories of the earliest measurable particles, as per Wheeler's 'self-excited circuit' invoking a 'strange inversion of the natural order of time'.* ***D****. Under these redefinitions, the measured CMB may be reconceived as a 'relative reference frame' that continuously and actively couples the participating observer, through time, to the primordial quantum substrate, intermediated by the associated particles of the early universe.* ***E.*** *In this 'continuous coupling' hypothesis, the large-scale pattern of quantum fluctuations imprinted on the registered CMB at any moment is conjectured to mirror the kinematic state (position and velocity) of the participating apparatus in spacetime, paving the way to explain the alignment and other CMB anomalies. Adjacent measurement apparatuses in separate regions of the universe (a, b) would therefore have independent 'relative reference frames', with associated congruent CMB patterns that may overlap, constructing a shared, objective reality.*

Based on this reasoning, the hypothesis logic continues that because all of the universe is continuously bathed in CMB radiation, participatory measurements of the earliest universe are continuously occurring throughout the universe. A *Participatory redefinition* of the initial conditions of the universe may therefore be stated as follows: at a universal scale, an ongoing ensemble of measurements is being continuously set upon the earliest radiation of the universe, thereby inducing a global pattern of wavefunction collapses associated with the actualization of this same radiation. In the Participatory picture, this interaction therefore continuously re-establishes the initial conditions of the universe as a 'live' retroactive boundary condition on its history, rather than as a single fixed event in the distant past, restating Wheeler's U-diagram and *'self-excited circuit'* (**Figure 8C).** While radically counter-intuitive, it is proposed below that this *Participatory redefinition* may offer a conceptual parallel to the events recognized as inflation, while also naturally anticipating several specific anomalies in CMB measurements that are otherwise unexplainable by standard cosmology.

First, viewing the early universe through this participatory lens achieves a conceptual analogue to the putative inflaton field, while appealing only to ingredients already present in standard quantum theory and general relativity. In the Copenhagen Interpretation, wavefunction collapse is associated with the emergence of definite measurement outcomes and particle content. Because such collapse is inherently non-local and instantaneous, it is posed that its application at the scale of the entire primordial universe allows for the simultaneous establishment of correlated conditions across the entire observable horizon, effectively achieving this role of inflation without requiring a new scalar field. Similarly, this framework suggests an alternative way of thinking about the Horizon Problem: it attributes the uniformity of causally disconnected regions not to thermal equilibration, but to a universal coherent measurement act performed on the early universe in the present. This radical interpretation thereby trades the usual dynamical picture of inflation for a description in terms of a non-local actualization of information, offering a distinct ontological alternative for its physical mechanism. It also recasts questions about the origin and direction of cosmic time in terms of participatory boundary conditions, without invoking retrocausality (since the *'iron rods'* of established history remain immutable, and only the undefined *'smoky dragon'* is resolved), relies solely on fields known to the Standard Model, and reframes the initial singularity within the closure of a 'self-excited circuit' without invoking events external to the universe. The apparent profound temporal paradox implied in this model can be explicitly reconciled by recalling Wheeler's conclusion from his delayed-choice experiments that "*the past has no existence except as it is recorded in the present*".(15)

Before next approaching unexplained anomalies present in the measurements of the CMB, we consider the following. Under the redefinitions above, the CMB can be reconsidered: not as a 'frozen relic' or 'rest frame', but rather a '*relative reference frame'* always specific to the status of the observer at the moment of measurement. It is argued that any measured CMB frame is 'coupled' to the participating observer, meaning the pattern imprinted on the registered CMB mirrors the kinematic state (position and velocity) of the detector in spacetime. This model allows for infinite adjacent observers to occupy congruent relative reference frames (**Figure 8E**), thereby avoiding solipsism. While every observer actualizes a distinct reference frame, these frames are mutually congruent and overlapping, constructing a shared, objective reality consistent with Wheeler's concept of 'interconnected measurement webs' (**Figure 4**). Altogether, this framework presents the necessary context to approach the large-scale CMB anomalies.

Hypothesis C*: Large-Scale CMB Anomalies*

Beyond delayed-choice, Wheeler expressed difficulty in reducing his Participatory universe to be 'plausible and testable', noting "*My trouble? Lack of a paradox or contradiction to focus attention*".(10) This section presents the hypothesis that CMB anomalies present multiple opportunities to compare the Participatory model to empirical data.

The first anomaly concerns unexpected and curious alignments of the CMB quadrupole and octopole with each other, with the ecliptic plane, and with the solar system's motion through space.(23) These anomalies have been reported across multiple independent analyses, with the probability of this constellation of alignments occurring by chance estimated in some studies to be of order 0.1% or less. If real, such alignments would violate the Copernican Principle of an isotropic, homogeneous universe without special significance ascribed to Earth's location.(24,25) In addition, these data would pose a profound temporal paradox, given a ~9 billion year separation between the release of the CMB photons and the formation of the solar system's geometry. There is currently no clear mechanism for why the CMB at largest scales would align with our solar system. However, the conjecture is presented here that these anomalies may be reconcilable through the participatory principles introduced above.

It is currently debated whether the CMB's ecliptic alignment is a true feature of the early universe or is caused by local factors skewing observations. However, viewing the CMB from its *Participatory redefinition* above may synthesize these perspectives. Per Hypotheses A and B, the measured CMB is not a pre-existing classical 'fog' but a ‘relative reference frame’ actualized by the detector's measurement; and because the observer in the *“here and now”* terminates the superposition by creating an irreversible record, the specific history actualized may be hypothesised to be inherently coupled to the detector's kinematic state. Consequently, the resulting map of CMB photons would appear skewed relative to the position and motion of the recording apparatus, creating an artifact of 'apparent centrality' that mirrors an observer’s geometry (**Figure 9**).

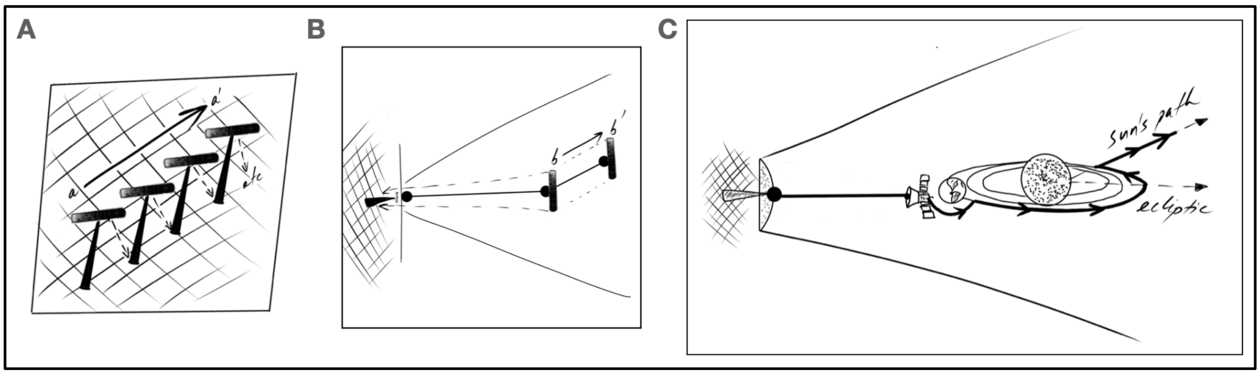


Figure 9*. Visual thinking diagram: a participatory hypothesis for the unexplained alignments of the CMB with the ecliptic plane and sun’s motion through space.* ***A****. A visual thinking diagram symbolizing that as an ‘iron rod’ of reality (refer* ***Figure 3****) moves in position (a to a’), it is continuously coupled to its substrate quantum field. As the rod interacts with its environment, its measurement status is continuously updated and perpetuated; but decoherence is not equivalent to measurement in this model.(26)* ***B****. When considering the Participatory framework in* ***Figure 8****, the CMB is not only considered primordial, but is simultaneously seen as a participant in the ‘here and now’ with the detector. It therefore follows that as an ‘iron-rod’ moves through spacetime (b to b’), it remains continuously coupled to the initial conditions of the universe through the relative reference frame of the registered CMB.* ***C****. This model anticipates that any overall map of CMB photons will therefore be skewed relative to the position and motion of a recording apparatus through space, which in the case of local Earth detectors, relates to the ecliptic plane and sun’s passage through space.*

A Participatory model could therefore naturally anticipate that the largest scale CMB pattern partially aligns with the solar system’s geometry and the sun’s motion through space via continuous coupling to our detector (**Figure 9C**). As measurements of CMB photons taken from anywhere in the universe would impart a similar artifact of ‘apparent centrality’ to the relative motion of a receiving instrument, this solution would preserve the Copernican Principle. That is, an observer situated in the Andromeda galaxy would actualize a distinct ‘relative CMB reference frame’, coupled to their own kinematic state and geometry, thereby finding a local alignment anomaly with their own perspective found central.

A natural question arises as to why such participatory coupling would predominantly affect the largest angular scales, as is currently observed.(23) Small scale anisotropies at large ℓ are interpreted as acoustic oscillations in the photon baryon plasma that were established by local causal physics inside the particle horizon prior to last scattering. Their pattern is therefore strongly constrained by internal microphysics and is expected to remain statistically isotropic. By contrast, the quadrupole and octopole correspond to modes whose wavelengths at recombination were comparable to or larger than the horizon, for which there is no robust local mechanism to fix phases and orientations. Within the present Participatory framework, it is therefore conjectured that any coupling between the CMB reference frame and the geometry and motion of the detector would imprint itself most strongly on these global, horizon scale modes, while being superseded at smaller scales by the dominant influence of local physics.

Critically, a Participatory framework would further predict that the observer's motion must appear different when measured against the CMB versus incoherent matter. That is, if the CMB is a 'relative reference frame' actualized by the observer (**Figure 9C**), it is effectively coupled to the local detector in a way that distant matter is not. An effect of this coupling would be to dampen the apparent kinematic dipole of the CMB relative to the rest of the universe. This logic could provide a plausible explanatory mechanism for the persistent kinematic dipole tension reported across multiple independent surveys, and most recently discussed by Böhme et al, who report that the dipole measured in the radio galaxy distribution is approximately four times larger than that of the CMB.(27) In the present Participatory model, this 'bulk flow' illusion may be resolved as follows: the radio galaxies (which act as fully decohered, classical tracers of the matter frame) are interpreted as reflecting the observer's motion relative to the large-scale matter distribution, while the CMB dipole represents a participator-coupled reference frame.

Another unexplained deviation in CMB observations from ΛCDM Standard Cosmological Model predictions concerns the apparent missing angular spectral power at large scales >60 degrees.(28,29) The angular power at these scales appears very near to zero; and while multiple explanations have been offered, this remains an important open (though not statistically definitive) problem. The near absence of angular power on these scales may be interpreted as suggestive of a finite cut off or special scale, which, relative to the size of the universe when the photons were first released from the CMB, curiously corresponds almost exactly with the size of the present observable universe. There is currently no widely accepted cosmological explanation for this anomaly.

Per the Participatory redefinition of the CMB (Figures 6 and 8), a resolution to this problem may be hypothesized as illustrated in the visual thinking diagram in **Figure 10**, whereby the absent power is attributed to a failure to actualize correlations on the largest angular scales. Recalling **Figure 8E,** this would occur because the participant's observable universe and CMB reference frame are relative, being actualized in unison by wavefunction collapse at the moment of measurement. Under this hypothesis, correlation modes corresponding to angular separations larger than ~60 degrees effectively lie beyond the participatory horizon of a given apparatus, meaning that correlations for such widely separated directions may remain in an unmeasured superposition. From the detector's perspective, this manifests as a vanishing two-point correlation function on those scales. Equivalent data would be obtained when measured from anywhere in the universe, hence this explanation remains complementary to the ΛCDM model. The temporal paradox introduced in this conjecture again recalls Wheeler's conclusion from delayed choice that any measurement made today has "*an irretrievable influence on what we will want to say about the past*".(15)

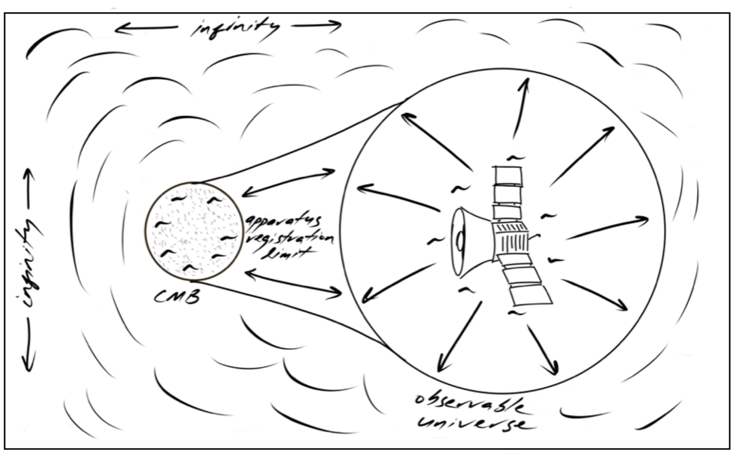


Figure 10. *Visual thinking diagram: participatory conjecture for the missing CMB angular spectral power at >60 degrees. Per* ***Figure 8E****, the participant's observable universe and CMB reference frame are relative. Therefore, correlations between CMB temperature fluctuations at angular separations beyond the effective participatory horizon of the present observable universe lie beyond the apparatus's registration limit, remaining in an unmeasured superposition.*

Speculative Horizons - Hypothesis D*: A Participatory 'Zero Energy' Universe*

Based on the above, an updated model of reality may be proposed to extend Wheeler's abstract visual-thinking 'R' diagram (**Figure 3)**. **Figure 11** presents an illustrative extension of this diagram, which proposes how a common coherent reality may be generated for shared observers in the '*here and now'*. Per Wheeler, this model hypothesizes that reality is perpetually rendered from a common quantum substrate, with continual reference to the continuously unfolding initial conditions of the universe, as a 'self-excited circuit'.

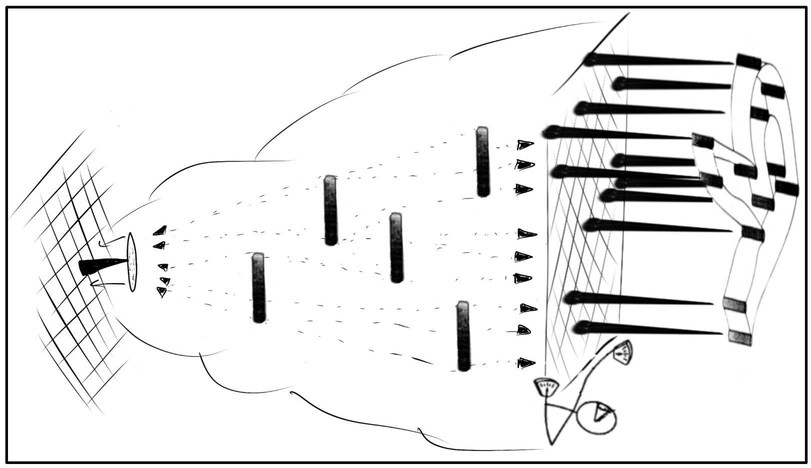


Figure 11*. Visual thinking diagram of an extended model of reality in the 'here and now' as rendered from a common quantum substrate by 'acts of participation'. The quantum substrate of the primordial universe and in the 'here and now' are one and the same. Over time, 'rods of reality' are increasingly generated and sustained through measurements, which share a common history, being coupled to the primordial quantum substrate through their congruent reference frames. Continual information exchange between these iron rods and the primordial universe actualizes reality in the present (****Figure 8****), while each new 'bit' of reality (e.g. measurement of CMB radiation as discussed above) joins reality with quantum probabilistic congruency.(9)*

A fundamental challenge arising with the hypotheses above, however, concerns the origins of the energy contained within the universe. In standard cosmology, the hot Big Bang model starts from an initial hot, dense state whose total energy content is effectively taken as given, rather than derived from more basic principles. Wheeler appeared to view such ideas with skepticism, preferring a zero-energy solution, stating "*how to get something from nothing should be the central issue of cosmology*".(10) He considered the participatory model as a path to a unifying solution, stating "*quantum mechanics and its number one feature, complementarity [are] decisive in bringing about all that is*",(10) and thus "*if we have one explanation for what is happening in the distant past, why should we need more*?"(30)

However, paths to a zero-energy solution within a Participatory model remain underexplored. In addition, Wheeler anticipated a critical problem when considering an expanding participatory universe, noting (c.1998) "*How to deal with the ever-increasing debt that is run up? Who's going to 'go bail' for all these observers and observers of observers, etc.*"(10) This intuitive journal entry expresses a realization that cumulative acts of observation in a Participatory model, ultimately materializing all particles in physical reality, must be counterbalanced by an energy conservation principle. An initial conjectural approach to resolving these issues within a participatory zero-energy universe is therefore outlined below.

As per **Figure 8A**, the participatory model poses '*it from bit'*, whereby all elementary phenomena in reality are derived from a measurement on a substrate quantum field. However, if Wheeler's conception of the initial conditions of the universe is taken literally, per **Figure 8C**, it follows that a primordial universal wavefunction collapse must not only continuously render physical particles into reality, but also spacetime itself. This recalls Wheeler's statement that "*every it - every particle, every field of force, even the space-time continuum itself - derives ... its very existence... from the apparatus elicited answers."(8)*

Extending these ideas as a speculative horizon, and in order to attempt a consistent theory, every 'measurement' is here conjectured to entail a 'zero-energy transaction' on a quantum field. Unlike standard cosmology, which implies the actualization of the universe's mass-energy was a singular primordial event, this model frames it as a continuous, distributed process specifically driven by the 'engine of measurement'. In this transaction, each act of irreversible registration is taken to actualize a co-equal quantity of positive energy (mass-energy) and negative energy (associated with the gravitational potential of spacetime), in such a way that the net contribution to the global energy budget remains zero while the local configuration is progressively driven out of equilibrium (**Figure 12A**). Note that "negative energy" is used here in the familiar heuristic sense from zero-energy universe proposals, that is, as a global bookkeeping concept. This hypothesis anticipates the duality present in Wheeler's classic aphorism *"Spacetime grips mass, telling it how to move; mass grips spacetime, telling it how to curve.*"(31), while viewing these as complementary qualities co-actualized by measurement, rather than merely viewing mass as the pre-existing cause of spacetime curvature.

Hypothesizing every measurement as a zero-energy transaction could resolve Wheeler's 'increasing debt' concern, restoring consistency with energy conservation principles, while also converging with Wheeler's conception of a self-organizing universe among shared observers as '*matchsticks found on floor, picking selves up*' (**Figure 4**). This is because the current hypothesis presents the universe, based on ever-increasing cumulative measurements, as an increasingly out-of-equilibrium thermodynamic system. Such systems, as evaluated by Prigogine and others, pose potential to become self-organizing dissipative systems, capable of continuously generating complex order without centralized control, while generating entropy (32,33). More specifically, the 'dissipative activity' driving the proposed system is the continuous generation of informational entropy required to distinctively 'write' the history of the universe (*"irreversible acts of amplification*"), effectively 'burning' quantum potential to precipitate classical reality. This idea is summarized in the abstract visual-thinking diagram, inspired by Wheeler, in **Figure 12B**, and explained further in the discussion section.

Speculative Horizons - Hypothesis E*: Measurement acts as 'Feedback' within a Self-Excited Circuit*

As a final conjecture, in the scheme presented above, a feedback loop has been conceived to operate between the continuous *'it-from-bit'* exchange between the substrate quantum fields and continuously regenerating reality of the self-exciting universe (**Figure 12B**). Based on this self-exciting circuit model, a *redefinition* may be approached for measurement itself. Measurement may be hypothesized to act as the feedback mechanism operating within this circuit. In the language of self-organizing systems, this feedback mediates the flow between a 'source' (the quantum potential/substrate) and a 'sink' (the actualized particles interacting within reality). Such a flow would, in this framework, be expected to occur within the oscillating feedback loop of a universe conceived as a 'self-excited' system.(32,33)

As feedback is critical to determining growth rates within self-organizing systems, the resultant expansion rate of the universe would then depend on the density of participatory feedback occurring within it (**Figure 12B**). This would imply that as the complexity and number of measurements in the universe increase, the dynamics of the universe itself, including its expansion rate, may evolve in tandem. Conversely, in this thought experiment, if acts of measurement were to cease, the system would relax back toward its zero-energy equilibrium state.

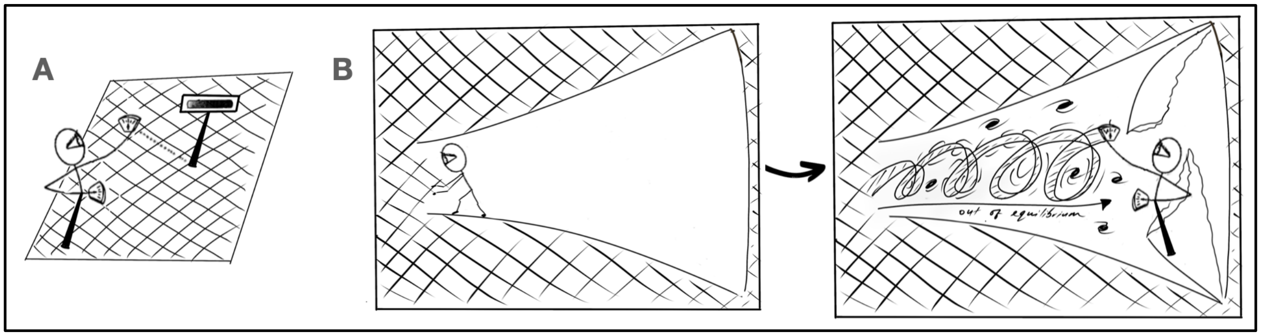


Figure 12*. Visual thinking diagram: schematic hypothesis of a measurement-mediated zero-energy universe.* ***A****. A measurement is conceived as a zero-energy transaction on a quantum field that actualizes a co-equal quantity of positive energy (mass-energy) and negative energy (associated with the gravitational potential of spacetime, in a global bookkeeping sense), bound in a balanced out-of-equilibrium state, such that if measurement ceases, then reversion to equilibrium occurs.* ***B.*** *Resultant visual thinking diagram of a Participatory zero-energy universe. Within this model, the universe is considered a balanced system that is out-of-equilibrium, with conservation principles naturally anticipated. With increasing accumulated measurements, the system operates increasingly further from equilibrium, leading to expansion and thermodynamic extremes between current and initial states, as dependent on feedback. The thermodynamic operations of the resultant out-of-equilibrium system could then be hypothesized to converge with Prigogine's description for a dissipative system, capable of self-organization with the resultant generation of complex 'order for free'.(32,33)*

Discussion

Wheeler began his autobiography "*We will recognize how simple the universe is when we can recognize how strange it is*."(2) This paper has been framed with the view that the Participatory model is being overlooked despite its potential to restate intractable problems in physics. By applying Wheeler's ideation techniques, an attempt has been made to introduce '*Participatory redefinition*s', being inter-related hypotheses that address CMB measurements and their inconsistencies, the initial conditions of the universe, the genesis of physical reality from a common quantum substrate, and a zero-energy universe. Through this series of radical redefinition hypotheses, expressed as highly abstracted 'ideas first' visual-thinking diagrams, it is conjectured that several intractable problems in the foundations of physics might be unifiable by this approach.

The explanatory power of the Participatory model arises from the principle of complementarity. This means that the proposed redefinitions do not seek to displace existing theories where they are supported by data, but rather to complement them with new properties. Wilczek paraphrased the complementarity principle as “*the realization that a single thing, when considered from different perspectives, can appear to have different, or even contradictory, properties*”, noting “*embracing divergent perspectives at the same time is a key to understanding reality*”.(34) Complementarity was introduced to physics by Bohr,(35) who viewed it a profound quantum truth and placed it symbolically on his knighthood coat of arms (**Figure 13; left**). The central thesis of this paper is that the full criticality of Bohr’s insight currently goes unrealized, contributing to enigmas and paradoxes in the fundamentals of physics, as symbolized in **Figure 13; right**.

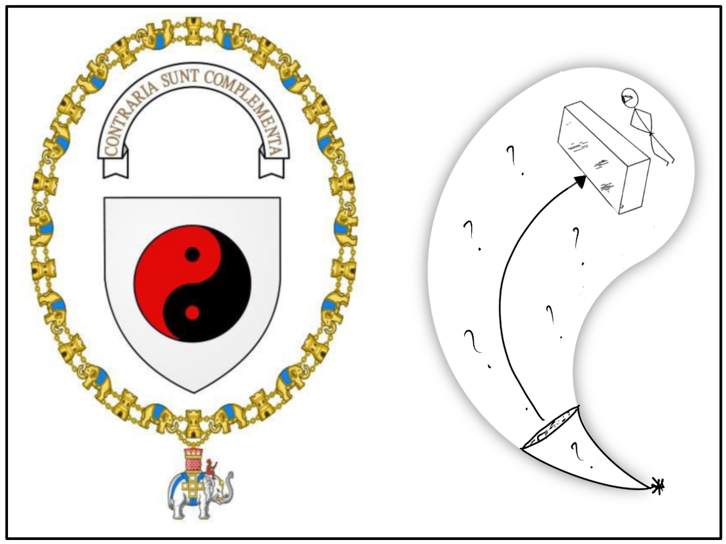


***Figure 13. Left**: The coat of arms that Bohr designed for his knighthood, bearing the ‘yin-yang’ symbol of duality, per Bohr’s view that the universe is composed of two opposing but complementary elements.* ***Right**:* Visual thinking diagram. *A symbolic representation of the current situation in physics referencing Bohr’s symbol, whereby complementarity might be being overlooked at the largest scales, leading to enigmas and paradoxes. The absent ‘yin’ is recognized in Bohr’s choice of symbol as representing ‘dark’, being quiet, passive, and harder to see, with the observer trapped behind Wheeler’s “one-foot-thick slab of plate glass without ourselves getting involved”.*

The hypotheses posed here provide an alternative path to approaching the initial conditions of the universe. The term Big Bang was famously coined by Hoyle as a skeptical moniker, in part due to his disbelief of a massive but finite quantity of energy being injected into the universe by unknown means.(36) While the general principles of the hot Big Bang model are strikingly successful, the problem of the initial conditions remains highly problematic. In addition, approaches to resolve the Big Bang’s inconsistencies have only introduced new layers of intractable complexity, such as unknown inflaton fields, many-worlds solutions, and physical events occurring ‘beyond the universe’. The alternative model discussed here, which Wheeler labeled ‘*a much more sedate affair’* in his private journals,(10) may ultimately offer a simpler conceptual path as it relies only on known physics and is congruent with conservation laws. Therefore, a conceptual framework compatible with the otherwise successful ‘Big

Bang' model may be proposed. In place of a 'multiverse', or a 'metaverse' (simulation), the new hypothesis could be labelled as a '*Measureverse'*, being a universe derived from bootstrapping, interconnected measurements, complementarity, and self-organization.

Although a 'Measureverse' might unify several current problems in the foundations of physics, other challenges are amplified. This includes the ultimate initiation problem of Wheeler's *'self-excited circuit*', which he encapsulated in the 'apt slogan' "*How does the whole show go?*"(10) While a 'feedback' hypothesis is proposed here as an engine for the operation and expansion of this circuit, the mystery of its origination was not explored. A Measureverse also brings the measurement problem clearly to the foreground, with all of the redefinitions proposed here unifying around its centrality. Wheeler's view was that "*One of the biggest problems is how to state the problem. It's an old saying that the minute you can state a problem correctly you understand 90 percent of the problem... The fact that it is difficult to talk about this problem in an easy way suggests that we have much to learn."(37)* Consequently, the hypothesis offered here poses measurement to relate to the 'feedback' within a universe that is an oscillating self-excited system operating out of equilibrium. It follows that the sophistication of this feedback will vary depending on the intricacy of the apparatus in question, with Wheeler's 'piece of mica' exhibiting less sophisticated feedback than a conscious human, but each ultimately capable of achieving an 'irreversible amplification that leaves a record'. However, the present model only proposes a conceptual reframing of the measurement problem, without solving it nor providing physical solutions.

The question is raised as to why the participatory model is overlooked in today's cosmology if it offers pivotal value, relies only on known physics, and was publicly developed by a highly influential physicist. Several reasons may be conjectured. First, it runs deeply counter to embedded Newtonian and Einsteinian realism. Second, Wheeler's unorthodox approach may have been difficult to assimilate, and he was still philosophically probing these foundational ideas at the time of his death, without clear applications to specific paradoxes or anomalies. Third, the model is radically counter-intuitive. Just as the acceptance of non-locality required a difficult paradigm shift away from local realism, the acceptance of a *Measureverse* would require a similar departure from temporal realism, being the assumption that the past exists independently of the present.

This paper has been deliberately framed as an initial highly abstracted set of integrated hypotheses rather than reducing ideas to mathematical theory. Wheeler reflected on a related challenge c.1996, stating: "*Yesterday Steven Weinberg espoused to me his discontent with any element of physics that does not lend itself to expression in pure mathematics. The "elementary quantum phenomenon, brought to a close by an irreversible act of amplification" bothered him ... Why any of this business, he asks, why not just the plain equations"*.(10) Wheeler instead prioritized intuitive and visual ideation of broad 'idea landscapes' before approaching formalism. The current approach therefore aligns with his philosophy of 'pre-geometry', which posits that the conceptual logic of a physical theory must be established before its mathematical formalism can be usefully constructed. The aim here is to articulate an initial coherent conceptual framework that can, in principle, be translated into quantitative models and empirical tests in future, with priority targets being the specific discussed CMB anomalies.

A Measureverse is conceived here as a far-from-equilibrium system. Some consider that Big Bang physics presents a thermodynamic paradox, as it describes a universe starting in a near-homogeneous thermal equilibrium that should become more disordered with increasing entropy through time; whereas expansion and cooling instead sees "*matter and energy condensed into a rich variety of ordered forms ranging from stars to living and thinking human beings*".(38) A Measureverse framework could address this paradox, because a far-from-equilibrium model may define initial conditions that more naturally fit with the concept of dissipative systems, which innately tend toward organization and complexity through self-organization (labelled 'order for free', due to a continuous balanced energy flux, and adaptive evolution at the 'edge of chaos').(32,33) These ideas were foreshadowed by Schrödinger, who theorized in his book '*What is Life*' that entropy and order are reciprocal (complementary) qualities, and that once the laws governing biological order "*have been revealed, [they] will form just as integral part of [physics].*"(39) This complementarity enables, as Schrödinger stated, both "*order from order*" and "*order from disorder*", with their combination naturally giving rise to the totality of complex forms and functions within nature (refer **Figures 11** ('order from order') and **12B** ('order from disorder') visual thinking modes respectively).(39)

Some aspects of Wheeler's model were not reviewed, including his idea of "mutability", whereby the laws of physics may be malleable.(4,16) One argument often advanced for a multiverse is that it supplies a weak anthropic explanation for finely tuned habitable conditions by providing an effectively unlimited ensemble of universes. Wheeler suggested an alternate possibility, that the laws of physics are not necessarily fixed but may evolve in a Darwinian manner toward conditions that permit complexity and life.(10) This suggestion, which prompted Feynman's comment that Wheeler "*sounds crazy... but...*" quoted earlier, is another instance of ideation by radical redefinition. However, if a Measureverse is a far-from-equilibrium system, then Wheeler's idea of mutability of physical laws, and even of the constants of nature, becomes more plausible, because adaptive evolution and self-organization are already well known to arise naturally at the 'edge of chaos'.(31,32) Recent work by Bassani and Magueijo explores a related idea, treating the early universe as a chaotic phase in which both the laws and the amount of matter can vary, and suggesting that more stable laws and matter content can emerge as an outcome of that evolution rather than as an initial assumption.(40) The present framework places a measurement-driven feedback loop as the central engine of an analogous process, albeit only at a conceptual level. In this light, Wheeler's aphorism '*law without law*' is interpreted as the proposal that all regularities themselves may be emergent products of the underlying participatory dynamics.(7)

Several caveats and open issues in this conceptual framework warrant specific comment. First, the motivation for a Participatory CMB rests on a cluster of cosmological tensions, each of which remains subject to debate regarding statistical significance and possible systematic origins. Should they ultimately prove artifactual, the empirical case for a coupled reference frame would weaken. Second, the framework extends Wheeler's "smoky dragon" picture to cosmological scales by radically asserting that CMB photons retain quantum superposition of release histories until ultimate registration. This runs profoundly counter to the standard view that environmental decoherence in the early universe already rendered those histories effectively classical. However, the decision not to simply identify decoherence with measurement is a central conceptual shift in the present proposal. In other words, on the present view, standard decoherence is dynamically correct but interpretively incomplete; it explains the suppression of interference and the emergence of stable pointer states, but not which of the many decohered histories is actual. In Wheeler's terms, a true measurement requires another kind of 'cut' in the smoky dragon, marked by irreversible amplification and thus the production of a single classical record, not merely entanglement with an environment. The present paper treats this ‘cut’ as an effective boundary associated with macroscopic, redundant, and enduring records, such as the CMB map generated decisively at the detector, rather than inferred prior path histories, yet defers a more precise definition to future work. Nevertheless, taking this distinction seriously at cosmological scales is what is offered as opening new approaches to CMB anomalies, as proposed here within a radical Participatory framework. Tentatively, the same logic might be extended to other cosmic puzzles in future, such as the vacuum catastrophe, by asking which formal contributions correspond to irreversibly registered phenomena and which remain unactualized quantum potential. In that sense, the great cloud of probability in Wheeler’s smoky dragon is treated as a general background against which the ‘iron rods of recorded facts’ stand out and become solely counted as ‘physical reality’.

Wheeler continued his search to comprehend reality until his death, expressing his central questions through a dualism: “*Why the quantum*; *Why existence*”?(2) Bohr, by contrast, made peace with this dualism through his great principle ‘*Contraria Sunt Complementa*’ (**Figure 13)**. This paper has attempted to review and extend Wheeler’s participatory model, based on the centrality of the quantum principle, while obeying only the known laws of physics in his spirit of ‘radical conservatism’. In doing so, it is proposed that Wheeler’s duality may be elevated to a triad, by accentuating what lies at the intersection in this hypothesis - measurement, as feedback between source and sink, which in this Participatory framework actualizes a self-exciting, self-organizing ‘Measureverse’.

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