Why do we measure in 3-dimensional physical space?

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Abstract

The constraints of three-dimensional measurement space are discussed. It is postulated that the new states in universe are being created and a macroscopic observer is allowed only three measurements between entropy change. The concept of parallel transport in GTR is used to explain the physical space as measured.

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We exist in three dimensions. It is as simple as that.

What it means is that we can describe most of the phenomena in terms of three axes x, y, z and time using the principles of conservation of momentum and energy. The description is based on how we perceive the world around us. Let us bring back the question we posed earlier, i.e. do we really know what an origin means?

Another question which arises based on our discussion so far is that if we can not measure a perfect zero then how can we be so sure that the angle between E and H is a perfect 90^o? May be it is $90^o+\delta$ or maybe it is $90^o-\delta$?

We can make an educated guess though. Let us reverse calculate the angle based on the value of alpha and the value of q = 3. It comes to a shade over 90^o ($\sim 90.77^o$). We need to be careful here as our experiments are very sophisticated and we would have detected right away that E and H were not exactly perpendicular. But we can still make a conjecture that E and H are at an angle $90^o+\delta$ where δ is extremely small, possibly in the Planck's domain.

We assign the role of the applied measurement force to E and the response to H which are correlated by Maxwell's equation. We can interchange their role keeping in mind that under relativistic limits E and H are not all that different.

Next we start developing the concept of the measurement space based on the observer capabilities.

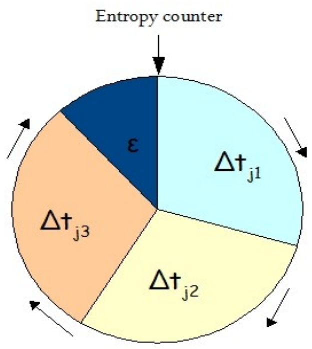
Measurement Space and Entropy

We have discussed the distribution of information in discrete j-space with q-values, where each q value represent a $PE1_j$ state. We visualize a measurement space for observer pair Obs_j in j-space where measurements must be completed to qualify as $PE1_j$ measurements, before the entropy of the environment is changed or equivalently the q-value is changed infinitesimally. It is as if the universe is changing right in front of our eyes except we can not detect it.

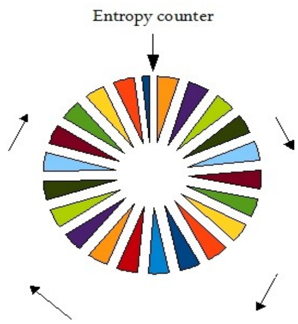
A measurement by the observer-1 of the Obs_j pair establishing the origin, is a $PE1_j$ measurement only as long as the entropy value does not change before the measurements by observer-2 of the Obs_j are completed i.e. $\Delta t_j \leq \Delta t_{entropy}$.

After the entropy change the observer-1 of the Obs_j pair, being used as a reference origin by observer-2 of Obs_j pair, will reset itself, and the next set of measurements are performed, independent of measurements performed prior to entropy change.

Consider the situation as shown in the adjoining picture. The areas in light color represent $PE1_j$ measurements. The area in dark blue represent an $PE1_j$ measurement which could not be completed before the entropy of the environment changed. The value $\Delta t_{entropy}$ represents the time interval between two consecutive entropy resets.



A much more efficient observer would be able to make a lot more measurements before the entropy change. However there is always at least one incomplete measurement which is a characteristics of the discrete measurement space. If the observers are able to match their measurements to the entropy reset, then they are already in i-space.



The Macroscopic Observer

We have defined the observers with varying capabilities. The Obs_i represents an observer with infinite capability compared to observer pair in discrete j-space Obs_j. Obs_i can determine the structure of the discrete j-space without applying a measurement force. Obs_i has the capability of determining the initial conditions or the limits for discrete j-space. Obs_j represents an observer pair with finite capabilities, making measurements in the discrete j-space where one of the observer is used as the reference origin. The capability limitations of the observers in discrete measurement space is based on the limitations of the measurement tools available to the observers.

We can envision an observer we can call a macroscopic observer, Obs_M, whose capabilities are further limited such that it is constrained by the lack of access to the observer-1 being used as reference-origin in discrete j-space. Thus Obs_M has no information about either the reference-origin as measured by the observer-1 of Obs_j pair or the absolute origin as determined by Obs_i. The macroscopic observer Obs_M will have no way of including the effect of entropy change in the measurement space, into its measurements which are made with EM measurement tools.

3-D

Let us consider the case of characterization of the j-space using measurement tools based on EM spectrum and the possibility that the angle between E and H is $90^o+\delta$, where δ is much below the measurement threshold, possibly in Planck's domain. In this case we have three $PE1_j$ measurements made by Obsj pair. We keep in mind that we are treating E and H as the measurement force and the response to the measurement force respectively.

Three $PE1_j$ measurements represent base states of long life-time or stable structures in j-space. The fourth non-$PE1_j$ measurement Δ represents the case in which EM signal is either partially or completely reflected from a discontinuity in discrete j-space.

Let us consider the actual situation where the measurements are made by a macroscopic observer Obs_M. The reported smallest interval for a measurement is 12 attoseconds or $12x10_{-18}$ seconds.

Reference:
Sebestian Koke, Christian Grebing, Harald Frei, Alexandria Anderson, Andreas Assion, Günter Steinmeyer, "Direct frequency comb synthesis with arbitrary offset and shot-noise-limited phase noise", Nature Photonics, 4, 462-465, 2010.

The time interval Δt_M between measurement force and measured response in this case, will be much larger than $3*\Delta t_j+\Delta$, which basically means that entropy counter will be set many billions of times during each measurement made by the macroscopic observer Obs_M. Therefore for Obs_M the reference observer-1 of Obs_j pair is not available and as a result the resolution of Δt_j states is not possible. The structure measured will be a composition of billions of $PE1_j$ measurements with three base states.

The structure described by measurements made by macroscopic observer in its own measurement space thus can be represented by a basis of three $PE1_j$ components at $90^o+\delta$ angle to each other. Due to the lack of resolution of Δt_j states for Obs_M the angle between components can be approximated as $90^o+\delta \approx 90^o$.

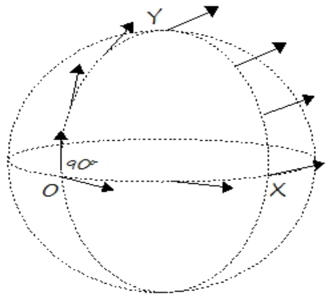
Thus for example a position vector r(x, y, z) measured by Obs_M between two points in physical space, can be represented as $r_x i + r_y j + r_z k$ where i, j, k represent coordinate axes orthogonal to each other . The argument applies to any measured quantity by Obs_M using EM tools in discrete j-space. Therefore the lack of reference or origin for Obs_M results in indistinguishableness of the base states and a 3D structure.

Can we still figure out why E and H are at 90^{o+} angle with each other? We can always make a guess but verification has to be made by measurements. The measurements in Planck's domain are not possible with our current capabilities.

Until our capabilities are further improved, let us make a rather amateur attempt and borrow the idea of the parallel transport from GTR.

If the path of a vector originating at O is along the arcs of great circles, the initial and final vectors are at 90^o angle to each other which is also how the macroscopic observer measures E and H. The ΔOXY represents the possible infinitesimal path in measurement space between force(E) and response(H) if the angle θ_{EH} between E and H is 90^o. For a macroscopic observer the sphere in

Planck's domain will be below its measurement resolution and hence transport of a measurement along an arc formed by great circles can be assumed. The value θ_{EH} is approximated as 90^o instead of $90^o+\delta$. Also the Obs_M will be measuring a large number of possible paths at least once, along great-circles during its measurements and hence a three dimensional picture results.



Parallel Transport: O -> X -> Y -> O

Let us continue our discussion along the same line (actually per Obs_i, drawing a perfectly straight line is not possible for a discrete space observer) and note that if the sphere was a two dimensional structure then initial and final vectors would have been parallel to each other instead of being perpendicular.

In terms of metric tensor, if we parallel transport a vector S_μ along a closed path C, the change ΔS_μ is given as

$$\Delta S_\mu = \frac{1}{2} R^\sigma{}_{\mu\nu\rho} S_\sigma \int_c x^\rho \, dx^\nu,$$

where $R^\sigma{}_{\mu\nu\rho}$ is Riemann-Christoffel curvature tensor. The change in vector ΔS_μ is zero if,

$$R^\sigma{}_{\mu\nu\rho} = 0.$$

Above condition represents a two dimensional space, where initial and final vectors are parallel. However in Obs_M case the initial and final vectors are not parallel to each other implying $R^\sigma{}_{\mu\nu\rho}$ is finite. Therefore the measurement made by Obs_M are in space with curvature or a three dimensional space. In other words the entropy limits the measurement of the information space and hence the observation to a three dimensional space for Obs_M. In the case of a spherical triangle of 90^o angle each the curvature tensor $R^\sigma{}_{\mu\nu\rho}$ reduces to $R = 1/r^2$. We know from GTR that inverse square law is followed for large R values. If we are looking at the Planck's dimension, the physical laws for the macroscopic observer will follow $1/r^2$ behavior.

To complete the argument the observer pair Obs_j will be measuring the δ_i (the extension of information space into discrete measurement space) in a either one or two dimensional space whereas the observer Obs_i will measure δ_i as a single quantum state of a shallow well or simply a point which represents a measurement without entropy. We will discuss the concept of observers with varying abilities further in later sections.

Just for fun we note that per Obs_i observation, Obs_M can not divide a sphere in exact eight parts by using EM tools because the angle θ_{EH} is ever so slightly greater than 90^o i.e. it is 90^{o+}.