Objective Reality of the Universe

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Abstract

This essay will analyze the role played by the observer and the measurement processes in our understanding of the reality. The measurement processes are both an aid and hindrance in our understanding of physical reality. These processes are helpful in regarding or disregarding new theoretical models. However, our dependence on quantification of physical quantities is inherent in theoretical models of the physical universe. The measurement processes are dependent on the physical disposition of the observer, and it is difficult to understand reality hidden behind such a reference frame.

Introduction

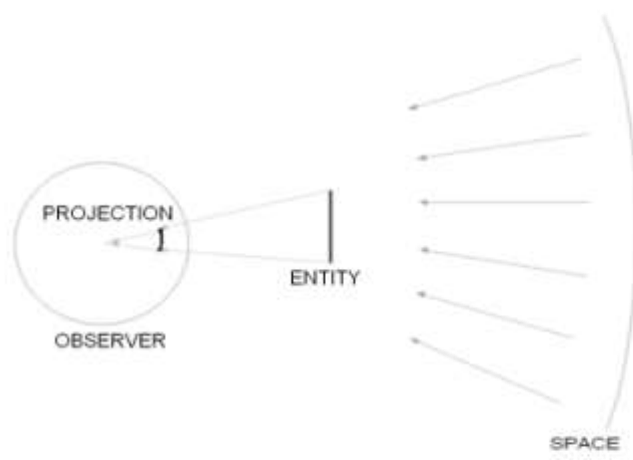
Following are some mathematical models, that may provide a relation between the observer and the physical universe, and explain whether reality, as a collection of all physical phenomenon, should be subjective. This implies that if a physical quantity is digitally represented for one observer, it should be digitally represented for all observers. Similar should be the case with analog quantities. However, below is an analysis as to whether this condition holds in our current theoretical models, or not.

Measurement model of a static one-dimensional case

Let us consider a physical quantity that can take real values within a finite range. We are not concerned whether the number of probable values are finite (discrete nature) or span the entire range (continuous nature). However, it is here stated and will be subsequently argued that the nature of such physical quantity (discrete or continuous) is independent of the observer's physical conditions, even though the actual measured value may be different for different observers.

To illustrate the above simply, we will consider only the classical example of length as a physical quantity **in one dimension,** and in a non-dynamic case, i.e. a **static space**. To measure length by visual observation (using light rays in classical sense), we will find that each 'point observer' may measure a different value of the length based on the observer's relative position in space. However, the nature of such quantity (digital or analog) is same for all observers.

Let me first summarize the process of measurement each observer may use to measure length, using rays. The observer here is defined as a point, i.e., a spherical entity with radius $\mathbf{R}_{\text{OBSERVER}} \rightarrow \mathbf{0}^{+}$. The observed length would be a projection of the real length entity on this limiting sphere. Also, the space itself is defined as an unlimited case of a sphere where $\mathbf{R}_{\text{SPACE}} \rightarrow \infty$. For the sake of observation, we imagine that this unlimited sphere emits rays from its surface towards its centre. Any typical geometrical entity will cast 'shadows' on the spherical observer's surface called its projection on this observer. In essence, this is a transformation of the infinite three dimensional space to a finite spherical surface. The process of observation is better illustrated in the figure below:



The above method of observation itself defines the point observer.

In case this quantity is discrete, the sample length will be made of many small length elements. Here, we are not concerned whether length is a discrete quantity or not, as we will analyze both the possibilities.

Now let us describe a typical physical entity as a line segment. In Euclidean space, this entity is a continuous aggregation of an unlimited number of infinitesimally small elements as below:

$$\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_$$

We define the length associated with this analog physical entity as:

$$\lim_{\substack{\delta\ell \to 0 \\ n \to \infty}} \mathrm{n} \times \delta\ell$$

For this physical entity, we can define such a digital quantity as:

$$\sum_{n} \mathrm{n} \times \delta\ell$$

However, the projection of the entity in either of above cases will have the same nature as the entity itself. This implies that although the value of this quantity may change for each observer as the projection may vary, the nature of the quantity is invariant of the observer, i.e. same for each observer and independent of the measurement conditions, in the static case.

Now, the above is a simple mathematical model, and may not represent the physical reality, as it is only a static case in one dimension. Let us consider the case wherein the observer and the entity are not in rest with respect to each other, and that instead of the imaginary continuous light rays, we are using, for example, an electromagnetic ray. In this case it may be possible that the observer observes an overlap of projection of various constituent elements of the entity. However, here lies the difference between the 'digital' and 'analog' forms, at least in case of length in Euclidean space. It is probable that the discrete entity may give a continuous projection on the observer (due to uncertainties and relative motion). However, a continuous one dimensional entity will never be projected as discrete in this scenario (check). To re-iterate, this is still just a mathematical model for a static case, and does not describe the real universe per se, as for that we will need to include the nature and limitations of experimental measurement of the quantity. However, it can be extended further to understand reality.

Let us extend the above model to three dimensional entities. In general, such an entity that is made up of discrete elements will form discrete image. However, if we consider that the constituent element density is so distributed in the bulk that each projection on the observer is a continuous one for each observer, there is no direct way for the observer to know through this measurement process, whether the entity is made up of discrete or continuous elements. This idea can be extended to better understand spatial quantization.

Existence of observer is requisite for scientific explanation of physical reality

Each physical phenomenon can only be explained if the underlying physical quantities are probably measurable, and for measurement of such physical quantities, a measurement process should exist. For such measurement, observation is required.

Let us consider the system of measurement that is inherently used in the Cartesian three-dimensional coordinate system. This system does not depend on observations by a single point observer as that would not measure the real value and different observers may disagree. In fact, in case of rectangular coordinate system, the property of position is defined by combining independent observations by minimum of three different observers situated at an unlimited distance from the origin. To keep things in perspective, it is re-stated that the system of position measurement used here through a point observer, **is the same as discussed in previous section**.

The existence of a reference set is also a requisite for physical measurement

Role of the process of measurement

The process of measurement is always based on a particular reference set. In case of the three dimensional coordinate system, this reference set is the union of different observations of three different observers. To elucidate further, the reference set in rectangular co-ordinate system is the union of three numbered lines. We can generalize this for measurement of length.

However, the important point here is whether can we generalize the above scenario for other physical quantities. Let us consider the example of measurement of Heat, as defined by the Zeroth Law of Thermodynamics. A simple statement of the law is as follow:

> If *A* and *C* are each in thermodynamic equilibrium with *B*, *A* is also in equilibrium with *C*

Here the observer set is B, because it is this set that is dependent on the reference set for determining its constituents. Either of A or C can be said to be the reference set, because either of these will help complete the range of possible values of the required physical quantity. (may require clarification as to why B is the observer). This defines the entire measurement process of heat as a physical quantity. Thus, considering hypothetically, if the possible values in the reference set, say A, are discrete, the process of measurement is itself limited to being discrete. Similarly, if the actual values span a continuous interval, the probable measurable values will belong to a continuous set. The above scenario is not pertaining to whether what experimental limitations are inherent in the measuring devices. This is only a mathematical model.

Now, it is very intuitive and understandable that the measurement process is inherently dependent on the observer. However, what can be realized from the above is that the measurement process also delimits the transformation of a real analog quantity to a discrete observation, or vice versa.

Let us now take the above model to a more physically appropriate level. We will now consider the naturally inherent probability measurements of the quantities, limited by physical conditions, experimental limitations, and theoretical limitations imposed by uncertainty principle.

Case I:

All the above factors will map the actual reference set for measurement (say A) to another mapped set B. Here we can state the following:

$$f: A \rightarrow B$$

In case that A is a discrete set, due to factors state above, B is not guaranteed to be a digital range. Corresponding to each discrete value in A, the mapped values in B may span an entire continuous range. Thus,

> For each, $a \in A$, there exists $b \in B$, **where b itself is a set** which contains probable measurable values, which in turn may span a discrete (digital) or a continuous range.

The final observation set is B. Thus, a digital quantity may be mapped as an analog quantity.

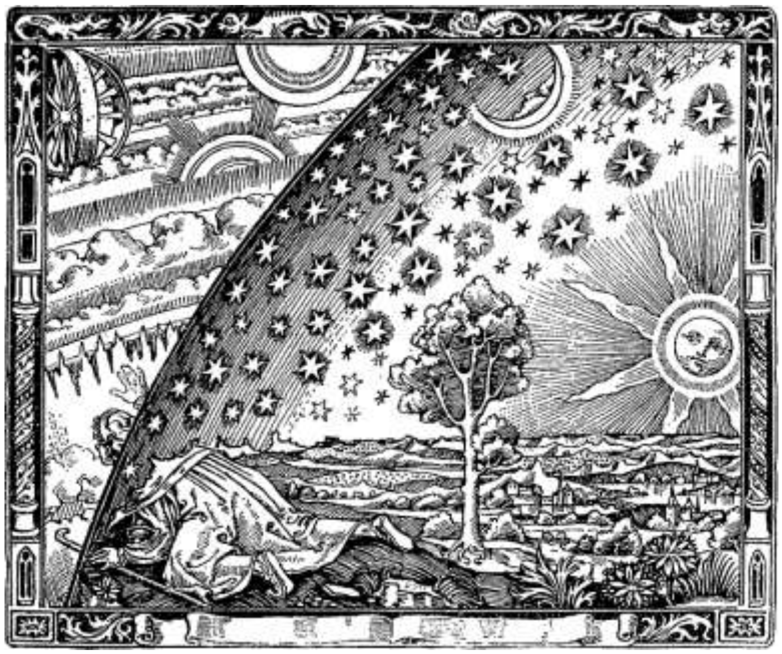
Case II:

Now, lets us consider the other case, wherein A is a continuous set. As delimited by experimental setups, we will always have a limitation on the accuracy. This implies that a continuous sub-range of values in A is mapped to a digital range.

Thus, *Case I* again leads to *Case II*, which is always the final observed output, i.e., a discrete set, in practice.

Conclusion

The observer as an interface, along with the reference set, causes the above dilemma. Reality itself is hidden behind the ‘curtain of the observable’, as depicted beautifully in the ‘Flammarion woodcut’ given below [1].



One may interpret the ’Flammarion woodcut’ subjectively, wherein a man is peeking through the ‘curtain of the sky’ to explore the workings of the universe. Alternatively, we can logically extrapolate the drawing from the ‘curtain of the sky’ to the ‘curtain of the physical universe’ symbolizing the current extent or limit of our knowledge of reality.

Physical reality is defined by physical quantities. However, practical factors as limitations of measurements provided by experimental values of physical quantities, and theoretical limitations imposed by uncertainty principle, hide the actual nature of such quantities. If the measurement process is taken a step further to replicate the physical states as is, and theoretical models be developed to consider the state of the quantity, rather than the value of the quantity itself, it can lead to a better understanding of physical reality.

References:

1. **'Flammarion Woodcut'**: Public domain image from Wikipedia available at http://en.wikipedia.org/wiki/File:Flammarion.jpg