The Quantum Of Continuity Essay, Research Paper

http://philosophos.tripod.comThe problem of continuum versus discreteness seems to be related to the issue of infinity and finiteness. The number of points in a line served as the logical floodgate which led to the development of Set Theory by Cantor at the end of the 19th century. It took almost another century to demonstrate the problematic nature of some of Cantor’s thinking (Cohen completed Godel’s work in 1963). But continuity can be finite and the connection is, most times, misleading rather than illuminating.

Intuition tells us that the world is continuous and contiguous. This seems to be a state of things which is devoid of characteristics other than its very existence. And yet, whenever we direct the microscope of scientific discipline at the world, we encounter quantized, segregated, distinct and discrete pictures. This atomization seems to be the natural state of things – why did evolution resort to the false perception of continuum? And how can a machine which is bound to be discrete by virtue of its “naturalness” – the brain – perceive a continuum?

The continuum is an external, mental category which is imposed by us on our observations and on the resulting data. It serves as an idealized approximation of reality, a model which is asymptotic to the Universe “as it is”. It gives rise to the concepts of quality, emergence, function, derivation, influence (force), interaction, fields, (quantum) measurement, processes and a host of other holistic ways of relating to our environment. The other pole, the quantized model of the world conveniently gives rise to the complementary set of concepts : quantity, causality, observation, (classic) measurement, language, events, quants, units and so on.

The private, macroscopic, low velocity instances of our physical descriptions of the universe (theories) tend to be continuous. Newtonian time is equated to a river. Space is a yarn. Einstein was the last classicist (relativity just means that no classical observer has any preference over another in formulating the laws of physics and in performing measurements). His space-time is a four dimensional continuum. What commenced as a matter of mathematical convenience was transformed into a hallowed doctrine : homogeneity, isotropy, symmetry became enshrined as the cornerstones of an almost religious outlook (”God does not play dice”). These were assumed to be “objective”, “observer independent” qualities of the Universe. There was supposed to be no preferred direction, no clustering of mass or of energy, no time, charge, or parity asymmetry in elementary particles. The notion of continuum was somehow inter-related. A continuum does not have to be symmetric, homogenous or isotropic – and, yet, somehow, we will be surprised if it turns out not to be.

As physical knowledge deepened, a distressful mood prevailed. The smooth curves of Einstein gave way to the radiating singularities of Hawking’s black holes. These black holes might eventually violate conservation laws by permanently losing all the information stored in them (which pertained to the masses and energies that they assimilated). Singularities imply a tear in the fabric of spacetime and the ubiquity of these creature completely annuls its continuous character. Modern superstrings and supermembranes theories (like Witten’s M-Theory) talk about dimensions which curl upon themselves and, thus become non discernible. Particles, singularities and curled up dimensions are close relatives and together seriously erode the tranquil continuity of yore.

But the first serious crack in the classical (intuitive) weltanschauung was opened long ago with the invention of the quantum theoretical device by Max Planck. The energy levels of particles no longer lay along an unhindered continuum. A particle emitted energy in discrete units, called quanta. Others developed a model of the atom, in which particles did not roam the entire inter-atomic space. Rather, they “circled” the nucleus in paths which represented discrete energy levels. No two particles could occupy the same energy level simultaneously and the space between these levels (orbits) was not inhabitable (non existent, actually).

The counter-continuum revolution spread into most fields of science. Phase transitions were introduced to explain the behaviour of materials when parameters such as pressure and temperature are changed. All the materials behave the same in the critical level of phase transition. Yet, phase transitions are discrete, rather surprising, events of emergent order. There is no continuum which can accommodate phase transitions.

The theory of dynamical systems (better known as “Chaos Theory”) has also violated long held notions of mathematical continuity. The sets of solutions of many mathematical theories were proven to be distributed among discrete values (called attractors). Functions behave “catastrophically” in that minute changes in the values of the parameters result in gigantic, divergent changes in where the system “settles down” (finds a solution). In biology Gould and others have modified the theory of evolution to incorporate qualitative, non-gradual ?jumps? from one step of the ladder to another. The Darwinian notion of continuous, smooth development with strewn remnants (?missing links?) attesting to each incremental shift ? has all but expired. Psychology, on the other hand, has always assumed that the difference between ?normal? and deranged is a qualitative one and that the two do not lie along a continuous line. A psychological disorder is not a normal state exaggerated.

The continuum way of seeing things is totally inapplicable philosophically and practically. There is a continuum of intelligence quotients (I.Q.s) and, yet, the gifted person is not an enhanced version of the mentally retarded. There is a non-continuous difference between 70 IQ and 170 IQ. They are utterly distinct and not reducible to one another. Another example : ?many? and ?few? are value judgements or cultural judgements of elements of a language used (and so are ?big? and ?small?). Though, theoretically, both are points on a continuous line ? they are qualitatively disparate. We cannot deduce what is big by studying the small unless we have access to some rules of derivation and decision making. The same applies to the couplets : order / disorder, element / system, evolution / revolution and ?not alive? / alive. The latter is at the heart of the applied ethical issue of abortion : when should a foetus begin to be considered a live thing ? Life springs suddenly. It is not ?more of the same?. It is not a matter of quantity of matter. It is a qualitative issue, almost in the eye of the beholder. All these are problems that call for a non-continuum approach, for the discrete emergence of new phases (order, life, system). The epiphenomenal aspect (properties that characterize the whole that are nowhere to be found when the parts comprising the whole are studied) is accidental to the main issue. The main issue being the fact that the world behaves in a sudden, emergent, surprising, discrete manner. There is no continuum out there, except in some of our descriptions of nature and even this seems to be for the sake of convenience and aesthetics.

But renaming or redefining a problem can hardly be called a solution. We selected the continuum idealization to make our lives easier. But WHY does it achieve this effect? In which ways does it simplify our quest to know the world in order to control it and thus enhance our chances to survive?

There are two types of continuum : spatial and temporal. All the other notions of continuum are reducible to these two. Take a wooden stick. It is continuous (though finite ? the two, we said, are not mutually exclusive or mutually exhaustive). Yet, if I were to break it in two ? its continuity will have vanished. Why? What in my action made continuity disappear and how can my action influence what seems to be an inherent, extensive property of the stick?

We are forced to accept that continuity is a property of the system that is contingent and dependent on external actions. This is normal, most properties are like this (temperature and pressure, to mention two). But what made the log continuous BEFORE I broke it ? and discontinuous following my action and (so it would seem) because of it? It is the identical response to the outside world. All the points in the (macroscopic) stick would have reacted identically to outside pressure, torsion, twisting, temperature, etc. It is this identical reaction that augments, defines and supports the mental category of ?continuum?. Where it ends ? discontinuity begins. This is the boundary or threshold. Breaking the wooden stick created new boundaries. Now, pressure applied to one part of the stick will not influence the other. The requirement of identical reaction will not be satisfied and the two (newly broken) parts of the stick are no longer part of the continuum.

The existence of a boundary or threshold is intuitively assumed even for infinite systems, like the Universe. This plus the identical reaction principle are what give the impression of continuity. The pre-broken wooden stick satisfied these two requirements: it had a boundary and all its points reacted simultaneously to the outside world.

Yet, these are necessary but insufficient conditions. Discrete entities can have boundaries and react simultaneously (as a group) and still be highly discontinuous. Take a set of the first 10 integers. This set has a boundary and will react in the same way, simultaneously, to a mathematical action (say, to a multiplication by a constant). But here arises the crucial difference:

All the points in the Stick will retain their identity under any transformation and under any physical action. If burnt ? they will all turn into ash, to take a radical example.

All the points in the stick will also retain their relationship to one another, the structure of the stick, the mutual arrangement of the points, the channels between them.

The integers in the set will not. Each will produce a result and the results will be disparate and will form a set of discrete numbers which is absolutely distinct from the original set. The second generation set will have no resemblance whatsoever to the first generation set.

An example : heating the wooden stick will not influence our ability to instantly recognize it as a wooden stick and as THE wooden stick. If burnt, we will be able to say with assuredness that a wooden stick has been burnt (at least, that wood has been burnt).

But a set of integers in itself does not contain the information needed to tell us whence it came, what was the set that preceded it. Here, additional knowledge will be required : the exact laws of transformation, the function which was used to derive this set.

The wooden stick conserves and preserves the information relating to itself ? the set of integers does not. We can generalize and say that a continuum preserves its information content under transformations while discrete entities or values behave idiosyncratically and, thus, do not. In the case of a continuum, no knowledge of the laws of transformation is needed in order to extract the information content of the continuum. The converse is true in the case of discrete entities or values.

These conditions: the existence of a boundary or threshold, the preservation of local information and the uniform reaction to transformation or action ? are what made the continuum such a useful tool in scientific thought. Paradoxically, the very theory that introduced non-continuous thinking to physics (quantum mechanics) is the one that is trying to reintroduce it now. The notion of ?fields? is manifestly continuous (the field exists everywhere, simultaneously). Action at a distance (which implies a unity of the Universe and its continuity) was supposedly exorcised by quantum mechanics ? only to reappear in ?space-like? interactions. Elaborate ? and implausible ? theoretical constructs are dreamt up in order to get rid of the ?contamination? of continuity. But it is a primordial sin, not so easily atoned for. The measurement problem (see: ?The Decoherence of Measurement?) is at the very heart of Quantum Mechanics : if the observer actively participates in the determination of the state of the observed system (which, admittedly, is only one possible interpretation) ? then we are all (observer and observed) members of one and the same continuum and it is discreteness which is imposed on the true, continuous, nature of the Universe.