

Structure of Time

First I introduce mathematical notion of group. We start with an example - the so called group of motions. One can move from point A to point B, and then move from point B to Point C. These two motions - first from A to B, and second from B to C, are equivalent to the motion from A to C. Thus product of two motions is also a motion. Next, any motion, also has an inverse, e.g., inverse of motion from A to B, is the motion from B to A. Finally, one has the concept of identity, or null motion, which is equivalent to not moving, i.e., staying at A itself. Any collection of objects, entities, satisfying these three properties of product, inverse and identity, form a mathematical group. For example set of all numbers also forms a group as follows -

Product of any two numbers is also a number. Any number has an inverse, such that product of a number and its inverse is one. Finally, the number 'one' is the identity, since multiplying any number by one, leaves it unchanged.

It turns out that notion of group plays an important part in mathematical physics. There is a beautiful theorem called Noether's theorem, which states that corresponding to any group structure in physics there exists a conservation law. For example, corresponding to the group of motions described above, the conservation law is that of linear momentum. Similarly, group of rotations in space also forms a group. For example, product of any two rotations is also a rotation. Corresponding to any rotation, there exists its inverse rotation. Finally, the identity element is null or zero rotation. The conservation law corresponding to group of rotations is that of angular momentum. Law of conservation of energy, which is among the most important physical laws, is related to group structure of time, from Noether's theorem. Time can have group structure as follows -

Time translation from moment A to B, followed by time translation from moment B to C, is equal to movement of time from B to C. Hence time satisfies the product requirement of being a group. Corresponding to time movement from A to B, there should exist an inverse movement from B to A (time flowing backwards). Finally, there should exist the null movement, which would correspond to same movement being repeated again and again (time standing still).

One assumes that time has group structure, because group structure of time is related to energy conservation, which is a verified fact. But given our subjective experience of flow of time, from past to future, how is the group structure of time getting created? Time does not stand still, therefore how does null element come about, alternatively, how can the same moment be repeatedly generated? Similarly, time does not flow backwards, so how does inverse movement from B to A (indicated above) get generated? Clearly, if time is linear (straight line), and its flow unidirectional, this cannot happen. Physicists try to wriggle out of this conundrum, by making their equation, time symmetric, i.e., they allow bi-directional flow of time - a sort of two way traffic. This is clearly incorrect, because time flow is one way traffic. However, in cyclic time, group structure of time is preserved, even with unidirectional flow of time. This is easily seen as follows.

Time being cyclic, means each event has infinite number of copies in past and future. Each event has occurred infinite number of times in past and will recur infinite number of times in future. Thus null element or identity does exist for cyclic time, because there exist movements which repeat the same event, - after integral multiples of time cycle. Also for any movement from event A to B, there exists the inverse movement from event B to A, via transiting over the complete remaining cycle. Thus time has group structure if it is cyclic, even though its flow is unidirectional. Clearly, linear time does not have group structure, with unidirectional flow of time. This is a very important observation, for it establishes cyclic nature of time, on the principle of energy conservation, and irreversibility of arrow of time.