Transition State Spacetime

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ABSTRACT

A mathematical model was constructed for the kinetics of spacetime relative to entropy states. The model design was created with reference to transition state theory (TST) which has been used to explain reaction rates of elementary chemical reactions. The model presented here applies TST to explain past, present and future based on change in entropy. Application of TST to spacetime shows that this theory of reaction rates is not merely a theory of chemical reactions, but can also apply to any rate process in physics involving events in space and time. It can also be used to begin to understand the distinction between flow of time and arrow of time.

INTRODUCTION

In describing the flow of time in physics, it is commonly held that time's direction flows from past to present to future. However, this thinking does not fit with the common metaphor that time flows like a river because it doesn't make sense that the river flows from the delta to its source or headwaters. This would be opposite to the direction of a river's current. Another perspective is that the flow of the river is from source to delta like the direction of the river current. Based on this perspective, time can be viewed to flow from future to present to past. That time involves future events are coming to be and then passing away is much like a chemical reaction in which the reactants progress to form products.

So what causes the river current to flow? It is the movement of water molecules and while the water that forms the current is always different, it is the collection of occurrences (events) and molecular interactions that makes up the flow. At the molecular level, river current can be viewed as a system of events involving interaction or collision of water molecules, one by one, in molecular motion.

Hence, here spacetime is modeled like chemical elements that undergo reactions based on reasoning from transition state theory for chemical reactions. Specifically, spacetime is modeled according to the theory of reaction rates for a unimolecular gas phase reaction according to the so-called thermal reaction in which molecule collisions are important. In these reactions the mechanism involves activation, deactivation and decomposition. The theory also assumes that an equilibrium exists between the reactant and the activated complex. Note that while the theory usually refers to chemical reactions of various kinds, this reference to chemistry does not restrict the application of the transition state theory to progression of other reactions. Here, the theory is applied to the progression of spacetime.

MODEL ASSUMPTIONS

The model, and the assumptions on which it is based, are given below. Note that, in the design, the rate constant "k" has spatial units of s^{-1} where s = space. Time and space variables in the model do not consider dimensions of time or space, but simply consider time as a dynamic variable of space. This is consonant with the real world as the physical measurement of time depends on changes in space.

1) Spacetime is considered to be made up of events that are in continuous motion and constant interaction, where an event is any change that happens or takes place in both space and time.

2) Time past (t_P), time now (t_N) & time future (t_F) events are distinct from one another.

3) Time now (t_N) is a transition state (low entropy state) between t_F and t_P in the progression of t_F to t_P (Note that this transition state is a different view from the common notion that progression of time mainly leads to an increase in entropy). Namely, time future (t_F) progresses to time now (t_N) which progresses to time past (t_P).

4) Time now (t_N) is also considered to occur at a point of reference anywhere in space where events progress in one direction and time flows from future to past.

5) In this view, some events, termed time future (t_F), are happening prior (upstream) to time now (t_N) and are coming to be in time now.

6) Other events, termed time past (t_P), take place later (downstream) than at the given point of reference of time now (t_N).

7) Interaction of two t_F events leads to increased "potential" (available) entropy and upon attaining sufficient entropy of activation, an instantaneous transition state (t_N event) is created.

8) Time past (t_P) arises from t_N as an irreversible reaction from t_N to t_P.

9) Given t_N is an instantaneous transition state, according to TST, a quasi-equilibrium exists between t_F and t_N.

MODEL EQUATIONS

$$t_F + t_F \xrightarrow{k_1} t_N$$

$$t_N \xrightarrow{k_2} t_F + t_F$$

$$t_N \xrightarrow{k_3} t_P + t_P$$

Time is measured as a sequence of interacting events in motion at a given reference point where time changes (*dt*) as a function of changes in space (*ds*). Time & space are entities expressed in terms of units of time and space.

$$\frac{dt_F}{ds} = 2\, k_2 t_N - k_1 t_F^2$$

$$\frac{dt_N}{ds} = k_1 t_F^2 - k_2 t_N - k_3 t_N$$

$$\frac{dt_P}{ds} = 2\, k_3 t_N$$

According to reasoning from transition state theory, a quasi-equilibrium exists between t_F and t_N. Therefore it can be assumed that:

$$\frac{dt_N}{ds} = 0, \text{ Thus, } k_1 t_F^2 = k_2 t_N + k_3 t_N \text{ and } \frac{dt_F}{ds} = k_2 t_N - k_3 t_N \text{ or } \frac{dt_F}{ds} = (k_2 - k_3)\, t_N$$

$$\text{Given that } \frac{dt_P}{ds} = 2\, k_3 t_N \text{ and } t_N = \frac{k_1 t_F^2}{(k_2+k_3)}, \text{ it follows } \frac{dt_P}{ds} = 2\, k_3 \times \frac{k_1 t_F^2}{(k_2+k_3)}$$

Thus, $\frac{dt_P}{ds}$ has first order and second order reaction properties in the progression of t_F to t_N to t_P.

Based on the above model design and assumptions, the general solution shows that all three eigenvalues are zero, i.e. $\lambda_{1,2,3} = 0$, and there are just two eigenvectors $v_1 = \begin{pmatrix} 1 \\ 0 \\ 0 \end{pmatrix}$ and $v_2 = \begin{pmatrix} 0 \\ 0 \\ 1 \end{pmatrix}$.

SUMMARY

Modeling spacetime based on reasoning from chemical kinetics and transition state theory provides a unique perspective on what it takes for spacetime to progress. This perspective gives insight into the distinction between flow of spacetime and arrow (direction) of spacetime. Based on reasoning from TST, three main factors need to occur in the progression of spacetime: (i). two future spacetime events need to interact at a given point of reference. (ii). A sufficient entropy of activation changes interacting future spacetime events to create a time now event that exists as an instantaneous transition state, (iii) when a time now event is created it instantly and irreversibly progresses to a time past event.

REFERENCES

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