# A Random Resistor Network Model of Space-Time

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A new model of space-time is proposed that incorporates the properties of a random resistor network. The self-similar nature of such networks is particularly useful in extrapolating force interactions to different levels of scale. By modeling time and matter as current and resistance, respectively, a simple equation for mass, time, and motion is derived that provides a novel mechanism for the displacement of matter.

*Keywords:* Random resistor network, space-time, redshift, gravity, speed of light

## Introduction

Recent cosmological observations suggest that prevailing models of space-time may not adequately describe certain phenomena, thus inviting the formulation of alternative constructs that address these unresolved issues [1-3]. To this end, we propose a new model in which space is not continuous, but is instead composed of infinitesimal pores. It is postulated that the properties of this porous universe correspond to those of other permeable materials, and can therefore be characterized in terms of percolation models. A useful feature of such models is their self-similar nature, which provides a means of determining force interactions at different levels of scale [4,5].

The proposed model incorporates the characteristics of a standard percolation system in which a potential gradient acts against a fluid-like material through a latticework of conducting sites. The effluent in this case is an extra dimension of time that permeates space through a network of interconnecting pores. The postulated diameter of the pores is small enough to preclude measurable interaction with surrounding space, thereby approximating the Planck length [6].

As in other percolation models, the flow of time would be limited by the probability that the connection between adjacent pores was either open or closed [7,8]. For open connections, time would flow into and out of our universe unimpeded. Conversely, closed connections would block the flow of time, resulting in a change in its potential, analogous to the displacement of current in a capacitor. This displaced timeflow would accumulate between the pores as charge potentials that comprise matter, consistent with the Standard Model [9].

None of the underlying postulates of the current model are completely new. The possible existence of extra dimensions of time has already been discussed [10], and the concept of pores is based on the idea that there is a lower limit to the amount of space that contains measurable information [6]. Nevertheless, the use of these postulates in the context of percolation models provides an entirely novel framework for relating mass, time, and motion.

## Formulating the Model

The current model incorporates the properties of a specific percolation structure, known as a random resistor network, where wires (bonds) are cut indiscriminately. In such a system, conductance between pores is associated with probability *p*, and zero conductance has probability 1–*p* [4]. Matter accumulates when a threshold value (critical probability) is reached at local sites within the network. Assuming every bond between the pores has the same conductance (G), mean current or timeflow (I) in response to the formation of matter is associated with an average voltage potential (V), and these values are related as follows [11]:

$$I = GV \tag{1.1}$$

Substituting resistance for conductance,

$$V = RI \tag{1.2}$$

The interaction of timeflow and matter in the network is thus identical to that of current and resistance in an electrical circuit, and can be expressed in terms of equation (1.2). As applied to matter (M) and timeflow (T), this equation would take the following form:

$$V = MT \tag{1.3}$$

where V is the potential associated with the matter.

The macroscopic behavior of matter would reflect its interactions at the level of the pores, and can therefore be described by established models of kinetic theory applied to a 3-dimensional, spatially uniform field. The electrophoretic movement of particles, as described by Smoluchowski, is a particularly appropriate model to examine the activity of charged matter in the current model, since it involves similar types of forces [12]. This model is valid for particles of any shape or concentration.

As applied to the current model, the electrophoretic movement of a particle would be proportional to its potential (V), and would continue until a state of equilibrium is reached. Any further movement would require the application of an external force to counteract the intrinsic potential of the particle (inertia), according to the following equation:

$$V' = V - V_i \quad (1.4)$$

where V' is the potential of the moving object, V is the potential of the object at rest, and $V_i$ is the counterpotential induced by work.

The above equation may also be expressed as follows:

$$MT' = MT - MV \qquad (1.5)$$

where M*V* is the momentum of the object.

Or,

$$MT' = M(T - V) \qquad (1.6)$$

And,

$$T' = T - V \qquad (1.7)$$

Or,

$$T - T' = V \qquad (1.8)$$

where T is the flow of time through the object at rest (expressed in the same dimensional units as velocity) and T' is the flow of time through the object undergoing movement.

The maximum change in timeflow (where T' is zero) would thus determine the upper limit for velocity ($V_{max}$).

$$T - 0 = V_{max} \qquad (1.9)$$

Or,

$$T - 0 = C \qquad (1.10)$$

The current model is therefore consistent with the relativistic concept of time dilation, where velocity C is associated with a timeflow rate of zero.

## Modeling Field Effects

In discussing the properties of the random resistor network, it was postulated that the pores had equal conductivity, producing a bimodal distribution of bond conductance. However, the accumulation of matter might result in a special case where localized voltage differences in the network alter bond conductance [11]. In a spatially uniform field, this process of "voltage trimming" would produce a symmetrical loss of conductance extending out from a given mass, thus assuming the properties of a field.

The magnitude of this field would be proportional to the mass of the object that produced it, and would be capable of inducing voltage drops in neighboring masses that result in movement according to the previously derived equation:

$$\mathrm{MT'} = \mathrm{MT} - \mathrm{M}V \tag{1.5}$$

Or,

$$\mathrm{MT} - \mathrm{MT'} = \mathrm{M}V \tag{2.1}$$

And,

$$\mathrm{M}\,(\mathrm{T} - \mathrm{T'}) = \mathrm{M}V \tag{2.2}$$

Or,

$$\Delta\mathrm{T} = V \tag{2.3}$$

With regard to gravitational fields, the increase in velocity ($V_{\mathrm{inc}}$) of an object falling from point a to b would therefore be determined by the magnitude of the change in timeflow from point a to b, where:

$$V_{\mathrm{inc}} = \Delta\mathrm{T}_{\mathrm{a\text{-}b}} \tag{2.4}$$

As the timeflow differential becomes larger, the object will undergo acceleration. Such a mechanism would produce the same effect as gravity, but would not require the postulation of a distinct gravitational force. It is entirely consistent with Newtonian mechanics, where mass does not affect the acceleration of a falling body. However, in contrast to relativity theory, there is curvature of time, rather than space, in proximity to mass.

## The Application of the Model to Cosmological Phenomena

The self-similar nature of percolation models implies that the arrangement of visible matter in the universe may be a reflection of what is occurring at the level of the pores. In accordance with a random resistor network, the probability of noncommunicating pores would yield a relatively homogeneous distribution of matter, consistent with the observed isotropic formation of galaxies within the universe. Furthermore, the model predicts that expansion of the universe could occur as a result of changes in the gating potential of the pores, which would be reflected by an increase in entropy [13].

Another interesting feature of the model is a predicted decrease in the rate of timeflow as the universe ages, a consequence of the continued accumulation of matter. Such a process would provide an alternative explanation for the greater degree of redshift at the boundaries of the visible universe. The timeflow differential ($\Delta T$) that developed between the light source (point a) and the observer (point b) over billions of years would result in an increase in the rate of their movement ($V_{inc}$) away from each other according to the previously derived equation:

$$V_{inc} = \Delta T_{a\text{-}b} \tag{2.4}$$

This would increase the redshift (Z) as follows:

$$Z \approx \frac{V_{\text{inc}}}{C} \tag{3.1}$$

For simplicity, we have only considered the case where $V_{\text{inc}}$ is much lower than C; however, the same mechanism would apply to higher velocities.

It should also be noted that the slowing of time has been suggested by others to explain why the rate of expansion of the universe seems to be increasing, but their proposed mechanism for the decrease in timeflow involves an entirely different theoretical approach [14].

# Conclusions

The current model is based on the application of percolation theory to space-time. A subset of percolation models (random resistor networks) yields a simplified relationship between mass and time, where these parameters are substituted for resistance and current, respectively. The important features of the model include infinite scalability and a robust mechanistic rationale for the Newtonian constructs of gravity, inertia, and uniform mass acceleration in a gravitational field, as well as the relativistic concept of time dilation in response to mass and velocity.

## References

[1] A.G. Reiss, A.V. Filippenko, V.Alexei, et al. “Observational Evidence from Supernovae for an Accelerating Universe and a Cosmological Constant,” *Astronomical Journal* **116** (1998) 1009-1038.

[2] S. Perlmutter, G. Aldering, G. Goldhaber, et al. Measurements of Ω and Λ from 42 High-Redshift Supernovae,” *Astrophysical Journal* **517** (1999) 565-586.

[3] W. M. Wood-Vasey, G. Miknaitis, C. W. Stubbs, et al., “Observational Constraints on the Nature of Dark Energy: First Cosmological Results from the ESSENCE Supernova Survey,” *Astrophysical Journal* **666** (2007) 694-715.

[4] A. Kapitulnik, A. Aharony, G. Deutscher, and D. Stauffer, “Self-similarity and correlations in percolation,” *Journal of Physics A* **16** (1983) L269-L274.

[5] A. Aharony, Y. Gefen, B. Mandelbrot, and S. Kirkpatrick, "Percolation, critical phenomena and fractals," In: *Disordered Systems and Localization*, Springer, Berlin. (1981) pp 56-58.

[6] W. M. Saslow, "A physical interpretation of the Planck length," *European Journal of Physics* **19** (1998) 313.

[7] S. Redner, "Conductivity of random resistor-diode networks," *Physical Review B* **25** (1982) 5646-5655.

[8] J. M. Luck, "Conductivity of random resistor networks," *Physical Review B* **43** (1991) 3933-3944.

[9] D. P. Roy, "Basic constituents of matter and their interactions - a progress report," *High Energy Physics-Phenomenology* (1999) ArXiv: hep - ph/9912523.

[10] I. Bars and S.-H. Chen, "Geometry and symmetry structures in 2 T gravity," *Physical Review D* **79** (2009) ArXiv:0811.2510.

[11] C. Grimaldi , T. Maeder, P. Ryser, and S. Strassler, "A random resistor network model of voltage trimming," *Journal of Physics D* **37** (2004) 2170-2174.

[12] J. Lyklema, "Electrokinetics after Smoluchowski," *Colloids and Surfaces A* **222** (2003) 5-14.

[13] F. B. Anders, E. Lebanon, and A. Schiller, "Coulomb blockade and quantum critical points in quantum dots," *Physica B* **359-361** (2005) 1381-1383.

[14] M. Mars, J.M.M. Senovilla, R. Vera, "Is the accelerated expansion evidence of a forthcoming change of signature on the brane?," *Physical Review D* **77** (2008) 027501.