I. Admitting Absolute Zero into Configuration Space

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September 25, 2003

Cosmologists are presently exploring and debating the end product of accelerating expansion and it may be that we collectively have yet to consider adequately its consequence on how we generally view reality. This paper in considering the role absolute zero plays in the set of all possible states recognizes that Boltzmann's logical explanation of why systems reach physical and thermodynamic equilibrium (the second law) is too simple to explain the *arrow of time*. Five modifications are proposed to how we presently model all possible states that result from admitting absolute zero into Boltzmann's order-disorder gradient.

Introduction

The publication of the Big Rip Scenario by Robert Caldwell and colleagues [1] in March is forcing a very fundamental issue to the surface which has previously remained obscure. If expansion stretches space-time flat in finite time, the path of time will have ended at the absolute zero of all known physics, what Caldwell refers to as the ultimate singularity. The potential of time ending in a Big Rip, and accelerating expansion in general, sharply indicate the need for cosmological science to consider the role absolute zero plays in an aggregate representation of all states (configuration space), the consequences of which are explored in this paper.

It seems rather odd in hindsight that cosmological science has not previously acknowledged absolute zero as having a location in the aggregate space of all possible states, in large part due to the absence of a zero state in Ludwig Boltzmann's logical explanation for *why* patterns evolve to a physical and thermodynamic equilibrium. Boltzmann introduced probability into physics with the argument that the disorder of a closed system increases due to a greater measure of disordered states compared to ordered states [2]. As Boltzmann first modeled the realm of all possibilities there was no reason to consider the role of absolute zero for ordinary closed environments settling to a non-zero equilibrium over short time durations. Early objections to the asymmetry of Boltzmann's model were eventually overshadowed by strong advocates, such as Sir Arthur Eddington who, in the 1920's, suggested a direct relationship between the second law and the universal arrow of time [3]. Whether it was Boltzmann's intent or not, the logic that *there are fewer ordered states than disordered states* eventually solidified into a modern cosmological paradigm representing the aggregate realm of all possible states.

If we graphically represent Boltzmann's model of states, along an axis the number of ordered states decreases toward an ever fewer measure of highly ordered states, while in the opposite direction the measure of increasingly disordered states increases. Referred to here as the *wedge model*, the large-scale structure of states has been reservedly portrayed as closing at the end of highest possible order at a single extreme state, while in the direction of increasing disorder the general assumption is of an endless and indefinite expansion of states without end.

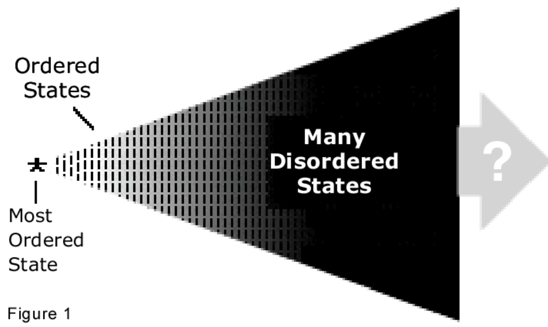
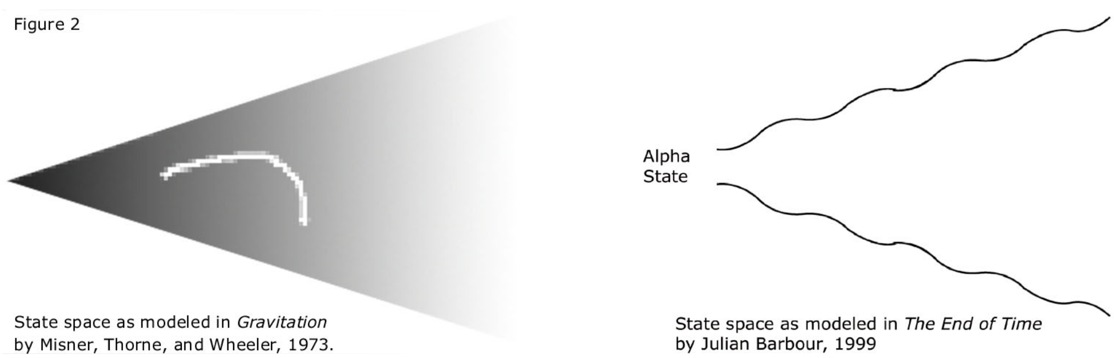


Figure 1

The asymmetric wedge model has become a vague yet rarely scrutinized construct for how we envision all possibilities, as well as the most popularly recognized cause for *why* there is an arrow of time [4][5][6]. However, the modern discovery of an accelerating rate of cosmological expansion indicates that Boltzmann's logic is too simple to explain either the cosmological or thermodynamic arrow of time.

Figure 2



State space as modeled in *Gravitation* by Misner, Thorne, and Wheeler, 1973.

State space as modeled in *The End of Time* by Julian Barbour, 1999

In any scenario where the expansion rate continues to accelerate, the evolution of space-time is forced to absolute zero in either infinite or finite time. If we consider configuration space during a period of time approaching or ending at absolute zero, all or nearly all states would exist in the opposite direction of the flow of time. It is a simple fact that the logic of Boltzmann's second law, in how it compares two groups of states, more ordered and more disordered, breaks down as an explanation for a direction of time aimed at and aligned with zero, since as the universe evolves to zero the body of all states becomes located in the direction of the past. Boltzmann's probabilities only work if there is a greater body of (disordered) states located in the direction of the future, which attracts the flow of time. With a greater body of possible states existing in the past, Boltzmann's logic demands a reversal of time.

In correlating the second law with the arrow of time, Eddington did not think to consider the role absolute zero might play in the deep time of cosmological evolution. In fact in hindsight we might recognize that the most fundamental properties of physics would be more appropriate as a guide to determining the aggregate structure of all possibilities, and not the order-disorder gradient which Boltzmann hypothesized for closed systems over limited time durations. Eddington appears to have been correct in concluding that the second law designates a heat death ending to the universe, however, in leaving zero out of the equation, cosmological science has since remained blind to the logical boundary of absolute zero, and even the inevitable gradation to zero, which necessarily must exist in any accurate representation of all states.

I. The Momentum of Time

Since 1998, studies of distant type 1a supernovae [7][8] combined with studies of the temperature variations in the cosmic microwave background (CMB) [9][10][11][12][13][14] have revealed that the expansion of the universe is accelerating. After decelerating for nearly eight billion years, it is now apparent that a dark energy force emerged approximately six billion years ago, beginning a unique period of cosmological evolution, where expansion accelerates rather than decelerates. In past attempts to trace the course of time cosmologists knew only that after the big bang the Hubble expansion established a decreasing momentum near enough to a declination toward absolute zero that the critical density omega appeared to equal one. With the course of time indeterminately riding the dividing line between a big crunch future and an end-less dissipation of heat there was no pronounced indication of an underlying intent to the evolution of the universe. Consequently, questions concerning the role and location of absolute zero in respect to Boltzmann's order-disorder gradient remained obscure. Presently neither the big crunch nor the heat death scenario of a decreasing momentum of expansion (not necessarily aimed at zero) accurately depict the future. In any continued acceleration scenario the direction of time is aimed precisely at zero, ending in either infinite or possibly finite time. In March, Robert Caldwell, Marc Kamionkowski, and Nevin Weinberg introduced the Big Rip Scenario [1], where a dark energy density dubbed phantom energy [16] by Caldwell increases with time and ends the universe in finite time by ripping apart galaxies, stars, and finally atoms.

Although the common point of absolute zero for all measures in physics, including mass, energy, density, gravity, and temperature, as a physical state has not previously played a major role in cosmological theory, there can no longer be any question as to the intent of cosmological evolution. In any continuous accelerating expansion scenario, the outer horizon of the space-time bubble breaks away from time zero and shrinks inward relative to each observer. This outer event horizon collapses and thus the event of space-time can be said to end in any scenario in which time approaches absolute zero. However, in stark contrast the process that produces the collapse of space-time is the physical expansion of space. And thus paradoxically the process of space-time coming to an end involves the physical universe stretching and transforming into an absolute flat space; the ultimate singularity. It thus becomes necessary to acknowledge the physical reality of zero as a possible omega state. The role of zero in cosmology now appears to be equal to that of the big bang's origin at an infinitely dense singularity. Time noticeably appears to begin at one extreme of nature and now appears to end at the other.

Presently considering a more fully exposed momentum of cosmological time, the proposal here is that absolute zero be recognized as a boundary state existing in aggregate state space, located beyond the bulk of all states of greater disorder [17][18][19]. My position will be that the physical equivalent of absolute zero is a four dimensional flat space singularity referred to here as a state of absolute flat space (AFS), a state considerably unique from the singularity of the big bang. I further suggest that cosmic acceleration plainly indicates AFS is the primary attractor in an aggregate configuration space, and shall explain that the crossover point between decelerating and accelerating expansion can be recognized as the beginning of a forced convergence toward AFS. We can initially represent a model of states with zero admitted as shown below, which keeps Boltzmann's logic partially intact, while suggesting the distinction between influences of state space on shorter and longer time durations.

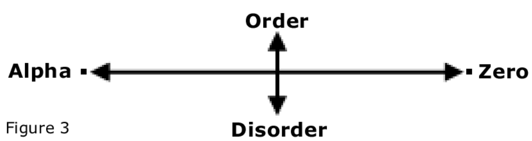


Figure 3

The second modification begins with generally considering the configuration space boundary issues of the distant future, which can be compared to similar state space boundary issues long recognized in our past. In reference to all states, the collapse of space-time volume at or near the beginning of time, referred to here as the alpha state, is generally assumed to be the highest state of order, if only because it is the extreme of possibility in physics in the direction of increasing order and low entropy. Once all known matter and energy is collapsed to a point of zero volume, physical descriptions end, and thus beyond an infinitely dense singularity [20][21] it is assumed here that no other possibilities exist. Likewise, here agreed to be the more ultimate singularity, the absolute zero of both temperature and density is the end of all scale in physics, and like alpha is also an ultimate boundary limit in an aggregate state space, beyond which no other possibilities exist, with the only exception to follow.

If we imagine the big bang in reverse, a deceleration in reverse time becomes an acceleration with the universe collapsing toward the alpha state. Considered in this way, all possible paths are converging in state space toward that extreme by the narrowing of possibilities, meaning the narrowing measure of states that construct the order-disorder wedge. In real time possible paths diverge away from alpha, but finally must converge toward absolute zero. Under the same principles which define the wedge model, we should recognize that there are fewer states of likeness to the singular extreme of zero than not, and thus similar to the decreasing measure of states surrounding the singularity at the beginning of time, aggregate configuration space is also shaped by a decreasing measure of states surrounding zero, meaning that the wedge reverses and closes toward the highest possible entropy at the end of time.

It is interesting to note that simply acknowledging the collapsing gradient to zero which inevitably belongs in an aggregate representation of all states leads to a probabilistic method of studying accelerating expansion, an approach which has previously been clouded by the modern assumption that the body of disordered states continues indefinitely. Finally a question becomes distinct that could be said to have been floating in the air since accelerating expansion was discovered. Considering all possible states, why is the evolution or arrow of time aimed directly at zero, and presently even accelerating toward zero? It should be noted here that there are already questions related to a breakdown in ordinary causality concerning the crossover from decelerating to accelerating cosmological expansion. Considering the late time emergence of an acceleration force we should question our expectations that the conditions of space-time are being causally forced to zero by events in the past, and equally consider the possibility that absolute zero is instead an attractor in our future.

However, if we recognize absolute zero in configuration space as a boundary and simultaneously consider it as an attractor we are led to question the model's asymmetry, merely to accommodate the momentum of time. The second law implies that disorder will increase only if a system originates in an initial condition of high order. If we were to treat absolute zero as the lowest possible disorder the question arises as to whether a system near zero existing in a condition of extremely low order should be expected to probabilistically gravitate toward greater order, and thus away from zero. What I mean this question to highlight is that once we admit zero into state space, inevitably placing it beyond the bulk of disordered states, so that we have a high order boundary and a low order boundary in an order gradient, there would logically exist a balance somewhere in state space between the two extremes of alpha and zero, meaning a point where a set of states of greater order is equal to a set of states of lesser order. The quantity of disordered states is then not necessarily always greater and the influence of the body of disordered states should decrease as a system approaches the ultimate balance between all states. We can therefore recognize a center position within the order-disorder axis which logically should act as a universal basin of attraction for all dynamic systems.

Yet if we consider what is known of the general evolution of space-time, there is no evidence to suggest the general direction of time is being drawn toward any such basin of attraction balanced between alpha and zero, or between the highest and lowest states of order. Instead indications are becoming ever more pronounced that the arrow of time is being directed precisely at zero, so that we must be highly curious about the attractive properties of AFS in the space of all possible states (SOAPS). While maintaining Boltzmann's general approach, we must speculate on how the SOAPS might be expanded so that the momentum of time toward AFS, as well as decreasing order and increasing entropy, can still be understood to be attributed to state space.

The most simple explanation for an arrow of time directed precisely at zero would be that a reciprocal negative set of states extends beyond zero. The overall structure of states would thus include an inverse set of patterns, similar to the extension of negative numbers beyond zero in the mathematical plane of real numbers, which are identical yet opposite. Departing fully now from Boltzmann's logically derived description of states, my central proposal is that absolute zero is the ultimate balance in aggregate state space and thus the primary attractor in the set of all possible states for all temporal systems, and that an inverse set of states verifiably explains the arrow and predictable course of time. This solution might feel intuitively satisfying since it eliminates the previous asymmetric version of state space. Actually a symmetric model is not only made necessary by the discovery of accelerating expansion but Boltzmann's modeling might also have been updated in this same way in the 1930's after Paul Dirac discovered the existence of anti-matter. This solution carries with it many implications so it will easily be evidenced or disproved. Before I more fully introduce the expected influence of an inverse set of patterns, it will benefit my argument to first point out that there also exists extremes adjacent to the axis between the alpha state and zero.

II. Adjacent Extremes

The modifications to how all states are modeled so far include introducing absolute zero, the converging structure of configuration space near zero, and the inverse group of states. We have modified the application of an order-disorder gradient to the deep time of cosmological evolution although we have not yet considered the structure of states at right angles to the deep time axis.

Note that we will now suspended the use of an order-disorder axis for deep time and instead utilize a more fundamental and imaginable gradient that is based on the average density of a state, which I will refer to as the average density gradient (ADG). In this fourth modification I will now consider separately the possible groups of states which exist adjacent to this deep time axis, which would logically influence systems in shorter time durations than the ADG. As mentioned, Boltzmann's wedge portrays an increasing measure of states in the direction of disorder, yet the limiting factors of this expanding axis, meaning the boundaries that bound the model into a wedge shape, are not explored. Notably there is a vague recognition in cosmology that a smooth configuration is an extreme of possibility or natural boundary in state space as the universe expands away from alpha, simply because a state cannot be more smooth than perfectly smooth.

My proposal here is that the adjacent axis of states is also bounded by two extremes. Similar to the alpha and zero states, these two extremes relate to the ordinary concept of contrast, where color tones are either blended into a single averaged color (low contrast) or the color tones of the image blend into two opposing shades of light and dark (high contrast). We can therefore identify a single extreme of smoothness along the ADG and using the contrast gradient further hypothesis a single extreme of lumpiness even if such a state is initially difficult to envision. It is suggested here that no possibilities beyond the smooth and lumpy extremes of the contrast gradient are describable by physics or even imaginable.

Space of All Possible States

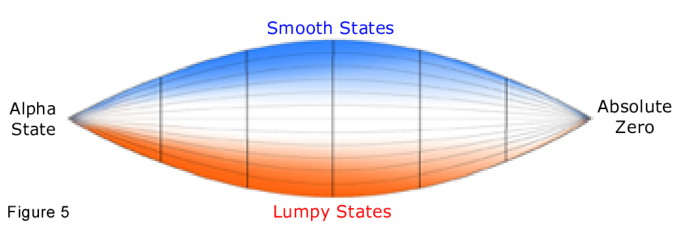


Figure 5

We have now produced a bounded and definite model of all possible states which allows us to consider the realm of all possibilities from a God's eye perspective. A top-down perspective toward physical reality has been defended by Piet Hut [22] and the necessity of a top-down approach to cosmology was very recently advocated by Stephen Hawking [23]. The proposal here is that boundary states exist in all directions of state space making the SOAPS definitive, as opposed to a model which is open and indefinite on the side of disordered states as is currently postulated. We can thus conclude that the realm of all possibilities is infinite yet bounded in all directions by extremes of physical possibility.

We can easily apply this gradient of low to high contrast to the question of why the early universe did not remain perfectly smooth. With similar reasoning as Boltzmann's original postulate, we can conclude that the maintenance of a smooth universe during expansion is statistically near impossibility. The universe remaining perfectly smooth is one possibility among many other possible states where space does not remain smooth. The suggestion here is that the path of a dynamic system along its deep time path from alpha to zero will probabilistically follow the basin of attraction balanced between the two contrast extremes, and that the measure of density variation detected since the big bang, and the present distribution of galactic matter, is congruent with this special phase space which expands during the divergence away from alpha and then contracts during the convergence toward zero.

III. General Probabilities

We can now begin a study of how the general probabilistic features of the proposed model would influence space-time, utilizing the same rational as it has been held that a greater number of disordered states influences a system. Boltzmann’s order-disorder gradient, or the wedge model, allowed only an indeterminate estimate of probability influence on cosmological time from an assumed open body of disordered states. This new model, in that the measure of states is bounded, leads to an extensive new field of probabilistic study. Improving the specificity of Boltzmann’s original attempt to model states now allows us to recognize the influence of four distinct groups of states, comparing the percentage of probability between four conditional directions of freedom.

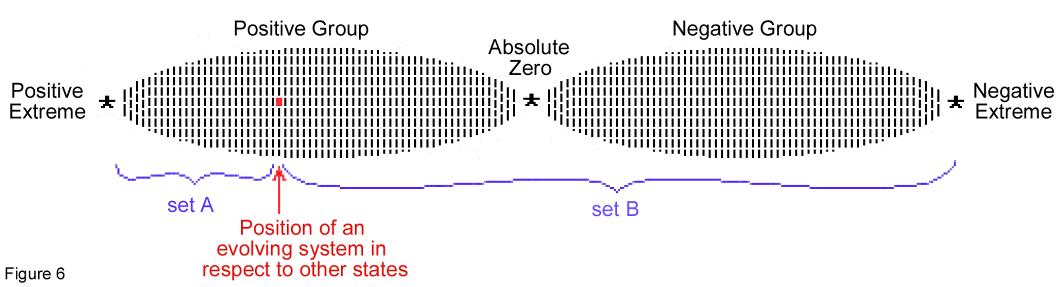


Figure 6

The diagram above considers the location of a single evolving system in respect to all other possible states. The larger set B includes all states which are less positive than the present state of the system, which we will refer to as the *Beta set*, while set A or the *Alpha set* includes all states which are more positive than the present state of the system, or those states related to the past. Although less forceful than the beta set, the counter influence of the past-like conditions of the alpha set, which are not directly considered in Boltzmann's model, is here recognized as having considerable influence upon the probabilistic flow of space-time, especially as systems approach absolute zero. The measure and probabilistic influence of set A is always the lesser compared to the Beta set, yet the influence of set A grows until the two sets become equalized as the system approaches zero.

In a complete quantum cosmology all forces of nature are probabilistic. In fact this approach suggests the forces of nature and cosmological expansion are conditional directions of freedom for the flow of time. If we consider a system at the position of the positive Alpha, at no time is the probability to travel toward zero greater. At alpha the beta set includes the total of all other states, which indicates an unconflicted probability without needing to escalate would drive or attract a cosmological system into its state space toward absolute zero. The properties of states between alpha and zero force the system to expand. As the system rapidly changes its location in configuration space the momentum toward zero immediately decelerates, slowed by the growing measure of states of set alpha which can be equated with a gravitational pull toward past-like conditions. The momentum of time is also moderately slowed by a growing measure of possible states adjacent to the contrast gradient's basin of attraction, which naturally compete with the states along the ADG axis. Clearly the general compatibility of these probabilities with expansion and gravitation would seem to clearly justify a more intense study, and the probabilities become much more complex as we consider the nature and order of a polarized Alpha state in competition with the attractive force of a neutral and uniform AFS state.

Once a space-time system enters the *Period of Convergence*, all previously divergent pathways of time crossover into a far different environment where the volume of state space narrows so that paths invariably become aligned into radial trajectories toward the single omega state of zero. Consequently, during convergence the future begins to influence the past. In a very real sense a zero future being the neutral balance of positives and negatives necessarily prepares the past in order to actualize itself. Such a trend toward balance would expectedly require for example that like particles repel and opposite particles attract. Eventually in this approach we depart from a view of time as a dimension and recognize that time travels in all available directions, and that configuration space and an otherwise free flow of time actualizes all force in nature and all physical structure.

Fig. 7 Possible time paths initially diverge away from an alpha state then converge toward zero.

In regards to the cosmological and psychological arrows of time, Boltzmann's logic indicates a system selecting from static patterns which themselves are not evolving, and in the fact that the logic of Boltzmann's model requires time to begin in a state of high order, denotes the early universe as an existentially odd state of being. Consequentially there has been no consensus toward any explanation of how a universe or time begins, which does seem logically impossible. Furthermore, if we merely admit zero into a gradient of states as the lowest possible order without including an inverse group, absolute zero is then as odd and is as equally improbable as the initial state of the big bang. These complications have contributed to the absence of absolute zero in our modern representation of all states.

This new symmetric model alternatively was developed by assuming a block universe view [17][18][19] where a system selects from states quiescently existing in physical form. As Boltzmann also recognized, each pattern, meaning each unique arrangement or distribution of matter, to a dynamic process, is equally probable. However, unique from Boltzmann's approach, in recognizing an inverse set of states, the logic here actually *expects* that observers positioned within a universe temporally structured by probability would detect that time originates from an ever more extreme imbalance.

It is possible then to recognize that in viewing one’s surrounding environment an observer will detect a space-time structure probabilistically determined by the alpha and the beta sets. Rather than a logic that indicates the early universe as odd, this polar model of states leads us to expect that temporal evolution we observe would inevitably originate with the universe accelerating at the most extreme rate allowed by nature away from an improbable state, directly toward the most probable. The configuration of space-time and memory thus correspond with the probabilistic structure of a symmetric state space.

In summary of this initial article we should make note of how the model thus far resolves major inconsistencies between the most basic physical properties known in physics and how we presently model all possible states based upon Boltzmann's vision of an order-disorder axis. A model of all states should exactly reflect physics, and although Boltzmann's approach is based conceptually upon order and disorder, all potential states should be at least generally locatable if the model is genuinely effective in describing all states. Absolute zero is unquestionably a fundamental axiom of physical existence, and the absence of any established location within aggregate state space of a state of absolute zero, or a gradation to zero, in the wedge model, parallels with its most irreconcilable feature; the endless indefinite extension of increasingly disordered states. This point can turn our focus now on how to re-integrate order and disorder into this evolved model, which is far more challenging that one might expect, since although zero is clearly the highest possible state of entropy, the most distinct property of an absolutely flat space is perfect symmetry, which obviously contradicts any designation of zero as the lowest possible order.

To explain the most significant modification brought about by the introduction of absolute zero to the SOAPS I must present a second article and therein propose a modification to how we understand order and disorder. What follows in the second article is probably the more consequential material of this report.

The author would like to thank Quentin Rowe, Dennett Netterville, and Emma Wilcox for invaluable discussions and support.

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