Thermodynamics and the Ontology of Time: Conservation and the Arrow in Block and Evolving Block Models (Version 2)

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***Abstract*—We examine whether thermodynamic considerations favor the Evolving Block Universe (EBU) over the standard Block Universe (BU). General relativity ensures local covariant conservation of energy–momentum, and statistical mechanics explains the arrow of time via the Past Hypothesis of a low-entropy boundary condition. We show that the BU is consistent with both conservation and thermodynamics when correctly framed. However, we argue that EBU may offer explanatory advantages: it grounds the sense of "becoming" in the thermodynamic arrow, reduces reliance on special boundary conditions, and potentially aligns ontology with irreversibility. Thermodynamics therefore does not rule out BU but provides a framework where EBU may be comparatively attractive.**

I. Introduction

Relativity theory by itself underdetermines ontology. The Block Universe (BU), in which all times coexist equally, is the dominant metaphysical interpretation, but alternatives such as the Evolving Block Universe (EBU) and Presentism persist. The thermodynamic arrow of time provides a fertile testing ground for these models. The question is whether conservation laws and entropy dynamics favor one ontology over another.

II. Conservation in Four Dimensions

A. Local Conservation

In general relativity, energy–momentum conservation is encoded in the local condition

$$\nabla_\mu T^{\mu\nu} = 0, \tag{1}$$

which guarantees continuity of fluxes along worldlines. Conserved quantities are defined on a Cauchy slice and propagated consistently to others; they are not summed across slices. The apparent "replication problem" disappears once this is understood: a particle's worldline traverses slices, but the particle is not multiply counted.

B. Global Charges

Global conservation (e.g., total energy) exists only in spacetimes with the relevant symmetries, such as asymptotic flatness (yielding ADM energy) or stationarity (yielding Komar integrals). In cosmological spacetimes, a global conserved energy is generally absent. Any argument that BU "violates conservation" must respect these constraints.

III. Thermodynamics and the Arrow of Time

A. Past Hypothesis

Statistical mechanics accounts for the observed entropy increase by postulating a special low-entropy initial condition (the Past Hypothesis). In a BU, the entire 4D history simply includes this boundary, and the entropy gradient is a global feature of the block.

B. Compatibility of BU

Contrary to some claims, BU is perfectly consistent with an entropy gradient. The arrow is defined as the direction of increasing entropy along timelike curves. The fact that the future "already exists" does not undermine the gradient.

C. EBU and Explanatory Virtues

EBU introduces an ontological "becoming," where the block grows as time advances. This aligns naturally with the thermodynamic arrow: the universe's "coming into being" mirrors the unfolding of irreversibility. One may argue this reduces explanatory reliance on an improbable Past Hypothesis, since the asymmetry is ontologically built in.

IV. Comparative Assessment

Rather than a table, we summarize the main contrasts here:

Block Universe (BU): Consistent with local conservation; global charges defined only in symmetric spacetimes. Requires the Past Hypothesis to account for entropy increase. Encodes the entropy gradient in a static block. Cost: all times exist equally, and the model relies on a finely tuned initial condition.

Evolving Block Universe (EBU): Local conservation laws respected as the block grows. The arrow of time is integrated into the ontological growth itself. Cost: departs from the standard spacetime ontology and remains less formally developed.

Presentism: Only the present slice exists, making conservation laws difficult to formulate relativistically. The arrow of time is trivialized (the present simply changes). Cost: strong tension with relativity and lack of a clear dynamical formulation.

V. Conclusion

Thermodynamics does not rule out the Block Universe. With proper treatment of conservation and entropy, BU is consistent with physics. However, EBU may offer explanatory benefits: it ties the thermodynamic arrow to ontological becoming and reduces dependence on special boundary conditions. The case for EBU is therefore comparative, not eliminative. Future work should formalize EBU dynamics within general relativity and statistical mechanics frameworks.

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