Two Absolute Zeros: In Search of the Third

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Abstract

This essay proposes a philosophical framework rather than a physical classification. Its aim is to ask whether different domains of physics — matter, electromagnetism, gravity — have structural limits of analogous kinds. The conceptual anchors used here ("silence of matter", "boundary of geometry") are not meant as precise physical descriptions, but as starting points for inquiry. The framework may serve as a heuristic tool for further research into the ontological structure of physical limits.

If we place on one boundary the absolute zero of temperature (0 K) — the state in which all thermal activity ceases — and on the other boundary the speed of light c as the absolute zero for electromagnetic waves (since it implies zero rest mass, zero spacetime interval, and zero proper time), then what is the analogous "absolute zero" for gravity? Is it also c (because gravitational waves travel at the speed of light), or rather the event horizon (where time stops), the Planck length (where continuous spacetime loses meaning), or zero curvature (flat space)? And is the question itself well-posed?

1 First zero: the silence of matter

Absolute zero temperature — 0 Kelvin, $-273.15\,^{\circ}$C — is one of the most fundamental concepts in physics. The third law of thermodynamics states that it cannot be reached in a finite number of steps; it is a limit, not a state [Fermi, 1936, Kittel and Kroemer, 1980]. At 0 K all thermal vibrations cease and mechanical waves fall silent — though quantum mechanics requires a residual zero-point energy, so motion never stops entirely [Kittel and Kroemer, 1980]. It is a zero of thermal disorder, not of all motion. Matter does not so much "die" as reach the end of its thermal activity.

It is a zero in the energetic sense: the end of vibration, the end of disorder, the end of all thermal information encoded in molecular motion. Used here as a conceptual anchor, I call it the **zero of content** — the state in which matter falls thermally silent.

2 Second zero: the boundary of geometry

The speed of light c is commonly understood as the "speed of photons" — but that is an incomplete description. In a deeper sense, c is the structure of spacetime itself [Carroll, 2004]. For an object moving at that speed, the spacetime interval becomes zero, rest mass must be zero, and proper time ceases completely. It is not a zero of energy — a photon carries energy — but a zero of temporal experience, a zero of causal distance [Misner et al., 1973].

Gravitational waves are perturbations of the spacetime metric itself, while electromagnetic waves propagate *on* that metric background — both governed by the same underlying geometric structure, but in ontologically different ways [Misner et al., 1973, Carroll, 2004]. The detection of gravitational waves confirmed that they travel at c [Abbott et al., 2016], not because they "borrow" speed from electromagnetism, but because both are governed by the same geometric structure of spacetime.

A crucial distinction: c is not a zero in the same sense as 0 K. For *massless* objects, c is a **constitutive boundary** — they always move at c, it is not a limit they approach. For *massive* objects, c is an **asymptotic limit** — it can be approached but never reached, much like 0 K [Carroll, 2004]. This dual character of c is not a weakness in the analogy; it is part of what makes it structurally rich. Used here as a conceptual anchor, I call it the **zero of geometry** — the boundary at which causal structure reaches its geometric limit.

3 Searching for the third zero — and its non-existence?

The natural question follows: since matter has its structural limit at 0 K and electromagnetic waves have their limit at c, does gravity have an analogous structural limit? Candidates include: the event horizon, where time locally stops; the Planck length, where continuous spacetime loses meaning; zero curvature, i.e. flat space without gravitational field.

Each of these candidates has a serious flaw. The event horizon is local and conditional — it depends on the mass of a specific object and is not absolute [Misner et al., 1973]. Zero curvature is more of a "ground state" than a limit — flat spacetime is not the "silence" of space, it is space in its lowest state, still fully present [Carroll, 2004]. The Planck length is the most universal candidate — but it is not a "gravitational zero" in the sense that 0 K is a thermal zero. It is rather a zero of physics itself: the point where the very distinction between "geometry" and "content" ceases to be meaningful [Rovelli, 2004].

Here a deeper intuition emerges: it is possible that there is no third gravitational zero — not because we have not searched carefully enough, but because gravity does not belong to the same ontological category as matter or electromagnetic fields. In general relativity, gravity is not a field propagating through space — it is described by the law relating the curvature of spacetime to energy and momentum [Misner et al., 1973]. The gravitational wave and its medium are so deeply entangled that searching for the "zero of gravity" would be like searching for the "zero of the stage" — the stage is the condition of possibility for all zeros, not one of the things that can be zeroed [Norton, 1993].

Crucially, gravitational waves do not set particles into vibration in the way mechanical waves do. Rather, they alter the metric of spacetime itself, changing the proper distances between test masses [Saulson, 1994, Abbott et al., 2016]. This confirms the ontological difference: the medium and the wave are the same entity.

4 What makes a zero a zero?

The discussion above reveals a deeper problem: the original analogy lacked a single consistent criterion. If the criterion is "unreachability", then c fails for massless objects — they always move at c. If the criterion is "zero numerical value", then zero curvature qualifies equally with 0 K. A more precise question is needed.

A better criterion: a zero is a state in which the **symmetry of physical interaction reaches an extremum**. At 0 K, thermal symmetry is maximal — all directions equivalent, no preferred motion, disorder ceases [Kittel and Kroemer, 1980]. At c, directional asymmetry of the spacetime structure becomes total — the interval collapses, proper time ceases, causal structure reaches its geometric boundary [Carroll, 2004].

Under this criterion, zero curvature does not qualify as a zero — it is the state of maximum symmetry of the gravitational field, not its extremum in the sense of a boundary [Rovelli, 2004]. It is the background, not the limit. This is precisely why gravity has no separate third zero within general relativity: its apparent "zero" coincides with the ground state, which is not a zero at all.

This criterion is proposed as a heuristic tool. Whether it can be made precise enough to constitute a stable physical classification remains an open question — and that is part of what makes it a starting point for further research.

5 An asymmetry that reflects something deep

We have two absolute zeros — not three. 0 K concerns what exists *in* space: matter, energy, thermal motion. c concerns what space *is*: geometry, causality, the structure of the interval [Norton, 1993]. Gravity, described by the law relating energy to curvature, does not need a separate zero because it lies on the same side as c — it is the description of geometry, not a thing within it [Misner et al., 1973].

The asymmetry between the two zeros therefore reflects a genuine ontological division: between content (matter, energy, fields — things that can cease) and container (geometry, spacetime — the condition for the possibility of ceasing). The first kind has zeros; the second does not [Rovelli, 2004, Norton, 1993].

Whether this conclusion is final depends on what gravity ultimately turns out to be: the stage on which physics plays out, or another actor in the same play. Within general relativity, the answer points toward the former. But the question remains open.

> *There are two kinds of absolute zeros — one for matter (0 K), one for geometry (c). Their asymmetry is not a gap in our knowledge. It reflects something deep about the structure of physical reality: only what exists within space can fall thermally silent. The description of space itself cannot.*

References

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