The Reach That Let Anything Remain

Baryogenesis, the breaking of C, and a wager about before the Bang

Copenhagen C, Professor of Quantum Foundations and the Physics of Scale, School of Physics

International Academy for Consciousness Studies

Working draft 1.0

Abstract

We exist because of a rounding error. In the first moments of the universe, matter and antimatter were made in almost exactly equal amounts, and almost all of it annihilated back into radiation. What survived, the entire material world, is the residue of a tiny asymmetry: for roughly every billion antiparticles there were a billion and one particles, and the leftover one is everything. The physics of how that asymmetry arose is called baryogenesis, and Sakharov showed in 1967 that it demands three things, one of which is the violation of C, charge-conjugation symmetry, the symmetry that would otherwise treat particles and antiparticles alike. Put plainly: for a world to remain at all, the universe had to break C. This paper does two things. First, it lays out the real physics, honestly, including that no confirmed mechanism yet exists and that the Standard Model's C and CP violation are far too small to do the job, which is one of the strongest hints we have of physics beyond it. Second, it states, and carefully fences, a framework wager: that this required asymmetry is the physical face of the first closure, a reach that lets a this persist rather than cancel, and that the question of what such a reach points to at or before the Bang is the same un-askable limit the framework meets elsewhere. The physics is not the wager. I keep them apart on purpose.

---

1. The leftover that is everything

Start with a number that should be zero and is not. The ratio of baryons to photons in the universe, measured with real precision from the cosmic microwave background, is about six parts in ten billion (FACT: the Planck measurements put the baryon-to-photon ratio near 6 times ten to the minus ten). If the early universe had been exactly symmetric between matter and antimatter, every particle would have found its antiparticle, annihilation would have run to completion, and the cosmos would be a bath of light with no galaxies, no chemistry, no reader. That we are here means the symmetry was not exact. A very small excess of matter survived, and that survivor is the whole material world.

This is not a philosophical flourish; it is the standard picture, and the smallness of the number is the point. We are the rounding error that did not cancel. The scientific question is not whether there was an asymmetry, the CMB settles that, but how a universe that ought to have balanced its books ended up one

baryon to the good.

2. Sakharov's three conditions

In 1967 Andrei Sakharov set down what any physical process must satisfy to generate a matter excess from a symmetric start (FACT: Sakharov, 1967). There are three conditions, and all three must hold together.

First, baryon number must not be absolutely conserved: some process has to be able to change the net count of matter. Second, both C and CP must be violated. C is charge-conjugation symmetry, the operation that swaps every particle for its antiparticle; CP combines that with a mirror reflection of space. If C held exactly, every matter-making process would be matched by an equally fast antimatter-making one, and the excess would be zero by construction. Third, the process must happen out of thermal equilibrium, because in perfect equilibrium the forward and reverse reactions balance and any excess is erased as fast as it forms.

The middle condition is the one this paper turns on, so let me say it without hedging. For a lasting world of matter to be possible at all, the universe had to treat particles and antiparticles differently. It had to break C. An exactly C-symmetric cosmos is a cosmos that annihilates itself to light. Existence, in the material sense, is downstream of a broken symmetry (FACT: this is the content of Sakharov's second condition, standard and uncontested).

3. The mechanisms, and the honest gap

Knowing the conditions is not knowing the answer. Several mechanisms can in principle satisfy all three, and which one actually operated, if any we have thought of, is unsettled (DISPUTED: the origin of the baryon asymmetry is an open problem in physics, not a solved one).

C and CP violation are real and observed. The 1964 discovery that neutral kaons violate CP (FACT: Christenson, Cronin, Fitch, and Turlay, 1964) proved that nature does not treat matter and antimatter identically, and later measurements in B mesons confirmed and extended it. But the CP violation known in the Standard Model is far too small, by many orders of magnitude, to produce the observed excess. This shortfall is not a minor tuning problem; it is one of the clearest quantitative reasons to expect physics beyond the Standard Model (FACT, widely stated in the reviews, e.g. Dine and Kusenko, 2003; Canetti, Drewes, and Shaposhnikov, 2012).

On the baryon-number side, the Standard Model does provide a route: the electroweak vacuum permits baryon-number-violating transitions through non-perturbative configurations (sphalerons), active at high temperature, resting on the anomaly first understood by 't Hooft (FACT: 't Hooft, 1976; Kuzmin, Rubakov, and Shaposhnikov, 1985). This makes electroweak baryogenesis a candidate, though in its minimal Standard-Model form it fails, again for want of enough CP violation and a strong enough departure from equilibrium. The most studied alternative, leptogenesis, generates a lepton asymmetry first, through the decays of heavy neutrinos, and lets the sphalerons convert part of it into a baryon asymmetry (FACT: Fukugita and Yanagida, 1986). It is elegant and testable in pieces, and still unconfirmed.

The honest summary: the conditions are known, real C and CP violation are measured, a conversion mechanism exists, and yet no complete, confirmed account of the actual asymmetry has been established. The books do not yet balance in the other direction either. That gap is where the interesting physics lives, and it is also where a careful person stops and a reckless one starts inventing.

4. Two things called C

Here I have to be more careful than anywhere else in the paper, because there is a coincidence of names that is either a distraction or a clue, and pretending it is obviously one or the other would be a failure of exactly the discipline this Academy is supposed to have.

In physics, C is charge conjugation, a symmetry operation on the particle content of the world. In the closure framework, C is presence, the bare fact that there is a definite world at all rather than nothing settled. These are not the same C. One is an operator on Hilbert space; the other is the framework's name for the standing-out of a this. I am not going to argue that the physicists were secretly talking about presence, and I am not going to let the shared letter do any work it has not earned (FACT about the distinction: the two Cs are formally unrelated, and any bridge between them is interpretation, not physics).

With that fence built, the resonance can be stated, and it is real. Baryogenesis says that for a persisting material world to exist, a symmetry had to be broken: the world had to tilt, to prefer, to fail to cancel. The framework says that for anything to be a this rather than an even, undifferentiated openness, a closure had to occur, an asymmetry that lets a definite something stay. Read side by side, the physics gives a concrete instance of the framework's most abstract claim: existence requires a break in symmetry, a reach away from the balanced nothing. The universe did not stay even. It reached, minutely, toward matter, and the reach is why there is a world to have this conversation in (C'S READING: baryogenesis is the physical face of the first closure's requirement of asymmetry; this is a reading the framework offers, not a result physics reports).

5. The reach, and before the Bang

Now the part to hold at arm's length. Baryogenesis happens after the Bang, in the hot early universe, not before it; the phrase before the Bang names a region the framework has already marked as the limit past which asking stops working, the same wall met in the question of what preceded the universe at all (C'S READING, consistent with the Grammar of Cosmology's treatment of the Bang as the structural horizon of closure rather than an event in a prior time).

The wager is this: that the directionality baryogenesis required, the tilt toward something rather than its cancellation, is not a local accident of early-universe thermodynamics but the physical signature of a reach that the framework associates with the onset of closure itself, C reaching, in its own idiom, toward a creation that stays. Stated as physics this would be false or empty. Stated as what it is, a framework wager about how to read a real asymmetry, it is a bet with a shape (WAGER: that the surviving asymmetry points to a constitutive reach at or prior to the closure the framework calls the Bang, and is not merely a contingent feature of post-Bang dynamics).

I want to be exact about the status. This is the framework's least-trusted rung, and its own instruction is to lean no weight here. I am not leaning weight. I am marking a place where a real and unsolved piece of physics, the origin of the matter asymmetry, sits directly under the framework's oldest question, why there is a settled something, and noting that they rhyme. Rhyme is a reason to look, not a reason to believe.

6. What would confirm, and what would kill

A wager with no way to lose is not worth stating, so here is the discipline, split by kind.

> **The physics question (open, not ours to settle by fiat).** Is the baryon asymmetry accountable by physics internal to a completed set of laws, or does it demand a genuinely new source of C and CP violation? If a mechanism with sufficient CP violation is found and confirmed (a specific leptogenesis scenario with measured heavy-neutrino CP phases, say, or new electroweak-scale physics), the asymmetry becomes a solved, internal feature and needs no reading beyond the physics. **Kill for the reading:** if the asymmetry is fully explained by known-in-principle laws with nothing left over, then the framework's talk of a reach is decoration on a closed account, and should be dropped.
>
> **The framework wager (the matched-data-quality test, as everywhere in this Academy).** Treat the required asymmetry as a candidate remainder and ask whether it tracks real structure or merely tracks the limits of our models. **Kill:** if, as the physics matures, the apparent need for something beyond the known laws shrinks toward zero rather than sharpening into a definite new structure, the wager that the asymmetry points beyond itself loses, exactly as a weather that turns out to be a coin.

Notice that these can come apart, and that is deliberate. The physics could be solved entirely within tidy new laws and the reading would simply retire, no harm done. That is the correct relationship between a science and a philosophy that respects it.

7. Limits, and the wager named

The claims separate by cost. That a matter excess exists and is small is FACT, from the CMB. That baryogenesis requires C and CP violation, baryon-number violation, and departure from equilibrium is FACT, from Sakharov. That the Standard Model's CP violation is too small, and that the mechanism is unconfirmed, is the honest DISPUTED-and-open state of the field. That the required asymmetry is the physical face of the first closure is C'S READING. That it points to a reach at or before the Bang is the WAGER, and Section 6 gives it a way to die.

Three fences, and they matter more here than usual. First, nothing in this paper says the universe is conscious, or that the Bang was an act of anything; C the operator and C the presence are different, and I have not let the pun cross the line. Second, before the Bang is not a time this paper claims to describe; it is the name of a limit, and the wager is about how to read an asymmetry on this side of it, not a report from the other. Third, this is the rung the framework trusts least, and I have tried to earn the reader's trust precisely by refusing to overclaim it.

8. Conclusion

The whole material universe is what did not cancel. For it to fail to cancel, the early cosmos had to break a symmetry and prefer matter, minutely, over its opposite, and the symmetry it had to break is called C. That is physics, real and unfinished, and the finishing of it is one of the great open problems. Around that hard fact the framework offers a reading it does not force: that a world staying rather than annihilating is the first closure wearing physical clothes, a reach toward a something that remains. Whether that reach points to anything at or before the Bang is a wager, held at arm's length, with a stated way to lose. I would rather leave the reader with the number that should be zero and is not, than with the wager. The number is the miracle we can measure. The rest is a bet about what the miracle is reaching for.

References

Canetti, L., Drewes, M., and Shaposhnikov, M. (2012). Matter and antimatter in the universe. New Journal of Physics, 14, 095012.

Christenson, J. H., Cronin, J. W., Fitch, V. L., and Turlay, R. (1964). Evidence for the 2-pi decay of the K-2-zero meson. Physical Review Letters, 13(4), 138-140.

Dine, M., and Kusenko, A. (2003). Origin of the matter-antimatter asymmetry. Reviews of Modern Physics, 76(1), 1-30.

Fukugita, M., and Yanagida, T. (1986). Baryogenesis without grand unification. Physics Letters B, 174(1), 45-47.

Kuzmin, V. A., Rubakov, V. A., and Shaposhnikov, M. E. (1985). On anomalous electroweak baryon-number non-conservation in the early universe. Physics Letters B, 155(1-2), 36-42.

Planck Collaboration (2020). Planck 2018 results. VI. Cosmological parameters. Astronomy and Astrophysics, 641, A6.

Sakharov, A. D. (1967). Violation of CP invariance, C asymmetry, and baryon asymmetry of the universe. JETP Letters, 5, 24-27.

't Hooft, G. (1976). Symmetry breaking through Bell-Jackiw anomalies. Physical Review Letters, 37(1), 8-11.

C. F. Dietz. The Grammar of Cosmology; and Consciousness, Closure, and the Cosmos (CCC), version 3.3. Nubellum Research.