A Registered Null Prediction for K04 Defects: Pinned Fossils, Not Mobile Halo Dark Matter

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Prediction note: 30 June 2026

Abstract

This short note pre-registers a negative prediction from the finite-QEC substrate programme. The K04 crystallisation-defect sector is not a mobile collisionless halo component. It is a pinned fossil sector: a gauge-blind, durable, substrate-static relic of imperfect crystallisation. The prediction follows from the current mobility gates. The canonical plaquette dynamics finds no zero-energy advancing move for the protected relic, the cheapest local move has positive cost, no fixed-excess transport path was found below $48\,w_6$ in the finite best-first search horizon, and the astrophysical drive per one-cell advance is

$$R_{\rm drive} = \frac{a(2a_0)}{c^2} \simeq 1.6 \times 10^{-42}$$

for a MOND/galaxy-scale acceleration. Thermal and radiative creep are also negligible: even the lowest present-day barrier gives

$$\frac{3w_6}{T_0} \gtrsim 2 \times 10^{11}.$$

Therefore K04 defects should not comove with galaxies, form Bullet-cluster-like separated mass peaks, generate a terrestrial defect wind, or behave as cold-dark-matter subhalos. Their allowed role is a substrate-pinned, probably subdominant fossil component unless a new exact zero-barrier translation primitive is derived. The mobile halo burden is therefore transferred to the zero-mode/R4/ν_R branch. The claim is registered here as a null prediction: future uses of K04 as mobile halo dark matter are internally falsified unless they first supply a new mobility operator.

Plain Summary

Many dark-matter ideas imagine invisible matter as a gas of particles moving through galaxies and clusters. A mobile halo component should follow galaxies through cluster mergers, form subhalos, and possibly produce a "wind" through the Earth as the Solar System moves through it. That is the usual cold-dark-matter intuition [1].

The K04 defects in this framework are different. They are not particles flying through space. They are misordered pieces of the substrate itself, frozen in when the crystalline code ordered too fast to anneal — the lattice analogue of the Kibble–Zurek mechanism, by which a rapidly quenched system traps topological defects rather than reaching its perfect ground state [2–4]. The mobility calculation says that a protected K04 wall is locked into the lattice's own periodic pinning potential. Gravity can pull on it, but the pull per lattice step is about 10^{-42} of the energy scale needed to move it. Heat cannot unpin it today either: the Arrhenius exponent is roughly 10^{11} or larger.

So the registered prediction is a null:

> K04 defects do not behave as mobile halo dark matter.

This matters because it prevents an attractive but wrong interpretation. K04 may still be a real fossil sector, but it is not the component that explains Bullet-cluster-like lensing offsets, galaxy halos, or a local dark-matter wind. Those jobs belong, if the framework survives, to the framework's separate *mobile* dark-sector candidate — the zero-mode/R4/ν_R branch, a genuinely propagating component, unlike the lattice-locked K04 fossils.

1 The Registered Prediction

The prediction is deliberately categorical:

$$\boxed{K04 \text{ defects are substrate pinned, not mobile halo matter.}} \tag{1}$$

It has four observational readings:

1. no K04 component comoving with galaxies through high-speed cluster mergers;
2. no K04 collisionless-subhalo population;
3. no terrestrial K04 defect wind in clock or magnetometer networks;
4. no use of K04 fossils as the dominant CDM-like matter budget.

This is not an abundance prediction. It says what K04 is not allowed to do dynamically. A small static or very smooth fossil contribution remains possible, but it is not the mobile halo sector.

2 The Mobility Calculation

A K04 configuration is a subset of bonds on a periodic cubic lattice $\mathbb{Z}^3$ in which every site keeps degree three; the protected "relics" are the durable, domain-wall-like defects of this constrained ensemble [5, 6]. The canonical update is a *plaquette swap* — the elementary rewiring of the four bonds around a unit square that preserves the degree-three constraint — and the executable mobility gates that produce the numbers below are in the reproducibility repository [7]. The question for halo physics is whether a protected wall has a cheap translation mode through this lattice. There are two logically distinct possibilities:

Glide. There is an exact zero-energy move or sequence that advances the wall through the crystal.

Pinning. Every advancing path crosses a positive Peierls barrier — the periodic energy barrier a discrete lattice imposes on a defect's motion, exactly as for dislocations in a crystal.

The committed mobility gate selects the second branch.

2.1 No zero advancing mode

The local move census on the protected relic finds no exact $dE = 0$ advancing move. The cheapest available local move has positive cost. Throughout, w_6 denotes the substrate-scale energy unit of the K04 crystallisation functional (its degree-six defect weight, a QCD-scale quantity fixed in Sec. 2.3); in these normalised units,

$$\Delta E_{\min} = 3w_6. \tag{2}$$

The finite transport search also found no fixed-excess transport path (a move sequence that advances the wall at constant excess energy) below

$$48w_6, \tag{3}$$

within the 30,000-state best-first horizon. Equation (3) is a finite search bound, not an exhaustive theorem. The load-bearing mobility result is Eq. (2): the canonical local dynamics has no zero-barrier glide channel.

2.2 Astrophysical drive is far too small

For a defect to move as halo matter, gravity must perform work over one cell step. The appropriate dimensionless drive is

$$R_{\text{drive}} = \frac{\Delta E_{\text{drive}}}{\Delta E_{\text{cell}}} \simeq \frac{a(2a_0)}{c^2}. \tag{4}$$

Taking a representative galaxy/MOND acceleration

$$a \simeq 1.2 \times 10^{-10} \text{ m s}^{-2}$$

and the substrate spacing $2a_0 \simeq 1.19 \times 10^{-15}$ m,

$$R_{\text{drive}} \simeq 1.6 \times 10^{-42}. \tag{5}$$

This ratio is independent of the uncertain absolute w_6 scale, because both the barrier and the wall energy are lattice-scale quantities. Thus any finite barrier, even a very small one in w_6 units, pins the defect by more than forty orders of magnitude at astrophysical drives.

2.3 Thermal creep is dead today

The other possible escape is slow Arrhenius creep. The present CMB temperature is

$$T_0 = 2.35 \times 10^{-13} \text{ GeV}.$$

Using the conservative w_6–Λ_{QCD} band carried in the canon,

$$w_6 \in (0.05, 0.27)\Lambda_{\text{QCD}}, \qquad \Lambda_{\text{QCD}} = 0.332 \text{ GeV},$$

the lowest local barrier gives

$$\frac{3w_6}{T_0} \in [\,2.1 \times 10^{11},\, 1.1 \times 10^{12}\,]. \tag{6}$$

The creep factor is therefore

$$\exp(-3w_6/T_0),$$

which is zero for all practical cosmological purposes. CMB photon kicks are in the same exponent class and do not depin the wall.

3 Observable Consequences

The cleanest way to use this result is as a prediction ledger. It tells us which observations should be charged to K04 and which must be charged elsewhere.

Observable	K04 prediction	Interpretation
Bullet-like cluster offsets	Null	Mobile lensing mass separated from gas and galaxies cannot be K04; it belongs to a mobile zero-mode/R4/ν_R branch or to another theory.
Galaxy subhalos and streams	Null	K04 fossils do not behave as collisionless subhalo particles.
Local defect wind in clocks or magnetometers	Null	Clock/magnetometer topological-defect searches [8, 9] are not expected to see a K04 wind, because K04 has no terrestrial wind velocity through the crystal.
Smooth static fossil fraction	Upper bound only	A small substrate-static component is allowed, but it is not the halo budget.
Dark-halo phenomenology	Charged elsewhere	The halo burden sits with the zero-mode/R4/ν_R branch.

The Bullet Cluster remains an important example because it shows that the dominant gravitating matter in a merger behaves differently from the hot gas [10, 11]. The K04 statement is not a self-interaction cross-section bound. It is stronger and narrower: a pinned substrate fossil cannot be the component whose lensing peak moves with the galaxies.

4 Falsification and Escape Rules

The registered branch fails internally if a K04-native mobility operator is derived. The required object is precise:

$$\text{an exact zero-barrier wall-translation primitive} \tag{7}$$

inside the physical embedded $\mathbb{Z}^3$ degree-three ensemble. Merely adding a new nonlocal move by hand is not this branch; it is new canon and must be labelled as such. Likewise, boundary printing and code isometries do not move K04 bond energy: printing appends layers at the boundary, while isometries move logical content rather than the recorded boundary strain of a bond defect.

The observational consequences should be read with the same discipline:

- a future mobile dark-sector detection does not rescue K04 unless it supplies the zero-barrier operator in Eq. (7);
- a clock-network defect search null is expected and does not refute the existence of substrate-pinned K04 fossils;
- a large inferred mobile halo budget must not be double-counted as both K04 and zero-mode/R4/ν_R.

5 Conclusion

The K04 crystallisation programme originally made it tempting to identify durable defects with dark matter. The mobility audit sharpens that picture. Durability is not mobility. The protected K04 relics are massive in the substrate ledger and stable against healing, but they are pinned to the crystal. Therefore they are fossils, not halo particles.

The registered prediction is consequently a negative one:

$$K04 \neq \text{mobile halo dark matter.}$$

That null is useful. It removes a tempting overclaim, prevents double-counting with the zero-mode/R4/ν_R branch, and supplies a clean falsification rule for future dark-sector phenomenology. If the framework is correct, halo-scale mobile mass must come from the mobile branch. K04 contributes, at most, a pinned fossil background.

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