Phenomenological Suppression of the Crossed Hypercomplex Term in the Halo Regime

Autonomous note

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Abstract

This note formulates a simple phenomenological argument for suppressing the crossed hypercomplex contribution in the dark-halo regime. The starting point is the empirical fact that dark matter halos do not generically collapse into thin disks in the same way baryonic matter does. In a hypercomplex multi-sector framework, this suggests that the dominant dark sector should remain effectively collisionless and weakly dissipative at halo scales. As a consequence, the mixed energy–momentum contribution built from the overlap of two internal curvatures is naturally assumed to be small or negligible in the halo regime. The argument is not an algebraic identity but a physically motivated effective ansatz.

1 Statement of the problem

Consider the crossed contribution to the effective energy–momentum tensor,

$$T^{(\epsilon)}_{\mu\nu} = \epsilon \left[\frac{1}{2} \operatorname{Tr}\Big(F^{(A)}_{\mu\rho} F^{(B)\rho}{}_{\nu} + F^{(B)}_{\mu\rho} F^{(A)\rho}{}_{\nu} \Big) - \frac{1}{2} g_{\mu\nu} \operatorname{Tr}\Big(F^{(A)}_{\rho\sigma} F^{(B)\rho\sigma} \Big) \right]. \tag{1}$$

A natural question is whether this term should be retained as dynamically important in the description of dark matter halos, or whether it should instead be regarded as small in the relevant astrophysical regime.

The working hypothesis proposed here is

$$T^{(\epsilon)}_{\mu\nu} \approx 0 \qquad \text{in the collisionless, non-dissipative halo regime.} \tag{2}$$

The purpose of this note is to justify why such an ansatz is physically natural.

2 Physical motivation: why baryons flatten and halos do not

A flattened galactic disk does not arise from gravitation alone. In order to form a thin disk, a component must be able to lose orbital energy efficiently while globally retaining angular momentum. Baryonic matter does precisely this through dissipative processes:

- radiative cooling,
- shocks,
- gas pressure and viscosity,
- star-formation feedback and subsequent relaxation.

Because of these mechanisms, baryonic matter can settle into a rotationally supported disk.

By contrast, the dominant dark matter component is usually modeled as effectively collisionless and weakly dissipative on halo scales. As a result, it does not cool into a thin disk in the same manner. Instead, it virializes into an extended halo, roughly spheroidal or triaxial, rather than a thin flattened structure.

This morphological difference suggests the following principle:

> If the dark sector possessed an efficient internal mixing or dissipative mechanism analogous to the baryonic one, one would generically expect a stronger tendency toward flattening, reorganization, or disk-like collapse.

Therefore, the observed persistence of extended dark halos strongly motivates a weakly dissipative and weakly mixed dark sector at halo scales.

3 Interpretation of the crossed term

The crossed contribution (1) is not, strictly speaking, a collision term in the kinetic-theory sense. It is rather an overlap or correlation term between two curvature sectors. This distinction is important.

Formally, (1) measures a mixed contribution built from

$$\mathrm{Tr}\Big(F^{(A)}_{\mu\rho}F^{(B)\rho}{}_{\nu}\Big), \qquad \mathrm{Tr}\Big(F^{(A)}_{\rho\sigma}F^{(B)\rho\sigma}\Big). \tag{3}$$

Thus, setting $T^{(\epsilon)}_{\mu\nu} \approx 0$ does *not* mean that the two sectors do not exist, nor that they cannot coexist gravitationally. It means that, in the relevant halo regime, their mixed overlap is sufficiently weak that it does not contribute significantly to the effective stress tensor.

The phenomenological reading is therefore:

> absence of efficient dissipation and absence of strong cross-sector coherence $\Longrightarrow$ suppression of the mixed hypercomplex energy contribution.

4 Three possible mechanisms for suppression

There are several physically distinct ways in which (2) may arise.

4.1 Internal quasi-orthogonality

The two sectors may be nearly orthogonal in the internal algebra, so that

$$\mathrm{Tr}\Big(F^{(A)}F^{(B)}\Big) \approx 0. \tag{4}$$

In that case, the mixed term is suppressed directly by the internal geometry.

4.2 Statistical decorrelation

The crossed contribution may be nonzero locally, but average to zero over halo scales because the relative internal orientations fluctuate rapidly:

$$\left\langle \mathrm{Tr}\left(F^{(A)}F^{(B)}\right)\right\rangle \approx 0. \tag{5}$$

This gives a natural large-scale effective suppression even if microscopic overlap exists.

4.3 Domain separation

The two sectors may occupy distinct effective domains, with only weak overlap in the halo bulk. Then the crossed term becomes negligible almost everywhere, possibly surviving only at interfaces or transition regions.

5 Phenomenological proposition

The previous considerations justify the following effective proposition.

Proposition 1. *In a dark-halo regime dominated by collisionless and non-dissipative hypercomplex matter, the crossed energy–momentum contribution*

$$\epsilon\left[\frac{1}{2}\,\mathrm{Tr}\left(F^{(A)}_{\mu\rho}F^{(B)\rho}{}_{\nu}+F^{(B)}_{\mu\rho}F^{(A)\rho}{}_{\nu}\right)-\frac{1}{2}g_{\mu\nu}\,\mathrm{Tr}\left(F^{(A)}_{\rho\sigma}F^{(B)\rho\sigma}\right)\right]$$

may be assumed to be negligible at leading order:

$$T^{(\epsilon)}_{\mu\nu}\approx 0.$$

This proposition should be understood as a phenomenological ansatz, not as an exact algebraic identity.

6 What this does and does not mean

The statement $T^{(\epsilon)}_{\mu\nu}\approx 0$ should be interpreted carefully.

What it means

- The two sectors do not build a sizeable mixed stress contribution in the halo regime.
- The dominant dark component remains effectively halo-like rather than disk-like.
- The model stays compatible with a weakly dissipative dark sector.

What it does not mean

- It does not mean that the two sectors are identically zero.
- It does not mean that they cannot coexist in the same spacetime.
- It does not mean that mixed terms are forbidden in all regimes.

In particular, the approximation may fail:

- in high-density environments,
- near interfaces between hypercomplex domains,
- in the early universe,
- or in strongly coherent internal configurations.

7 A useful formulation for a manuscript

A concise paper-ready wording is the following:

> Since dark matter halos do not generically collapse into thin disks in the same way baryonic matter does, the dominant dark sector is expected to remain effectively collisionless and weakly dissipative on halo scales. In a two-sector hypercomplex description, this motivates the phenomenological suppression of the crossed stress contribution. Accordingly, in the halo regime we assume
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> $$T^{(\epsilon)}_{\mu\nu} = \epsilon \left[\frac{1}{2} \operatorname{Tr}\Big(F^{(A)}_{\mu\rho} F^{(B)\rho}{}_{\nu} + F^{(B)}_{\mu\rho} F^{(A)\rho}{}_{\nu} \Big) - \frac{1}{2} g_{\mu\nu} \operatorname{Tr}\Big(F^{(A)}_{\rho\sigma} F^{(B)\rho\sigma} \Big) \right] \approx 0.$$
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> This approximation expresses weak cross-sector overlap or effective decorrelation, rather than an exact algebraic cancellation.

8 Conclusion

The non-flattening of dark matter halos provides a strong phenomenological clue: the dominant dark sector should not behave like a highly dissipative baryonic fluid. In a hypercomplex two-sector framework, this naturally motivates suppressing the crossed energy–momentum term at leading order in the halo regime.

The resulting approximation

$$T^{(\epsilon)}_{\mu\nu} \approx 0$$

is therefore best understood as a halo-level effective ansatz encoding weak dissipation, weak overlap, or weak coherence between the two hypercomplex sectors. It is not a theorem, but it is a physically well-motivated simplification.