Hier is een compacte Engelse versie die de theorie, de uitgevoerde tests en de beperkingen ervan als één artikel presenteert.

Vacuum.Net, Ternary Closure and the Physics of Swarming

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Abstract

Vacuum.Net proposes a physical description in which the fundamental structure is a continuous strand and the elementary event is its self-intersection. Each crossing has three possible relational states, represented by balanced ternary values:

$$T \in \{-1, 0, +1\}.$$

T\in\{-1,0,+1\}.
The central hypothesis is that persistent physical structures arise through closure: configurations that close can persist, whereas configurations that fail to close disperse or transform.

This article investigates a possible connection between this framework and the physics of collective motion, particularly the Vicsek model, phase synchronization, active matter, and topological defects. A provisional computational model was constructed in which local ternary relations interact dynamically and closure is given weak positive feedback. The simulations show that closure feedback can substantially increase the lifetime of closed configurations and that this effect is strongest at an intermediate coupling strength. These results do not establish Vacuum.Net as a physical theory; they provide a falsifiable computational test of one specific implementation of its proposed closure mechanism.

1. Introduction

Collective behaviour in physics provides an important example of how macroscopic order can emerge from local interactions. The classical Vicsek model demonstrated that locally interacting self-driven particles can undergo a transition from disordered motion to collective transport. Each particle aligns its direction with neighbouring particles while stochastic perturbations remain present.

Modern active-matter physics has extended this perspective to systems far from thermodynamic equilibrium. Collective flows, orientational order and topological defects can emerge without conventional equilibrium ordering. Topological methods have become particularly important because certain structures can be robust against perturbations through topological invariants.

Vacuum.Net approaches the problem from a different starting point. Instead of assuming particles as the fundamental entities, it proposes a continuous underlying strand. Self-intersections generate elementary relational states, represented by the balanced ternary values $-1,0,+1$. Physical structures are then interpreted as configurations of these relations.

The relevant question is therefore whether collective physical order can emerge from the same type of local relational dynamics.

2. The Ternary Structure

The fundamental local state is represented as

$$T_i\in\{-1,0,+1\}.$$

The three values represent the three possible relational states associated with a crossing.

A configuration can therefore be represented as

$$C=(T_1,T$$

2
,
…
,
T
n
)
.

$$C=(T_1,T_2,\ldots,T_n).$$

The central Vacuum.Net hypothesis is that a configuration becomes persistent when its relations satisfy a closure condition.

A minimal operational representation of closure is

C
(
C
)
=
1

$$\mathcal C(C)=1$$

when the configuration satisfies the selected closure constraints, and

C
(
C
)
=
0

$$\mathcal C(C)=0$$

otherwise.

It is important to distinguish this operational definition from a final derivation of the Vacuum.Net closure algebra. The computational experiment described below uses a provisional closure criterion specifically so that the hypothesis can be tested.

3. Relation to Swarm Physics

The connection with swarm physics does not require interpreting animals, particles or robots as literal Vacuum.Net structures.

The more fundamental correspondence is:

local interaction
→
collective organization
→
persistent structure
.

$$\text{local interaction} \rightarrow \text{collective organization} \rightarrow \text{persistent structure}.$$

In the Vicsek model, local directional alignment produces collective motion.

In Vacuum.Net, the proposed sequence is instead:

$$\text{local ternary relation} \rightarrow \text{closure} \rightarrow \text{persistence}.$$

A possible synthesis is therefore:

$$\boxed{ \text{ternary structure} \rightarrow \text{local dynamics} \rightarrow \text{closure} \rightarrow \text{collective order} }$$

This differs from conventional swarm models because the relational structure itself is allowed to participate in the dynamics.

4. Connection with Synchronization

A second comparison is with coupled oscillator systems. In Kuramoto-type models, local phase coupling can produce synchronization. Synchronization is a collective phenomenon in which many oscillators become dynamically correlated.

A conventional order parameter is

$$R= \left| \frac{1}{N} \sum_{i=1}^{N}e^{i\theta_i} \right|.$$

Here

$R\approx0$ corresponds to weak global phase coherence, whereas larger R indicates collective phase order.

Vacuum.Net introduces a different kind of order:

$$C= \frac{N_{\mathrm{closed}}}{N_{\mathrm{tested}}}.$$

Thus two independent observables can be distinguished:

$$R=\text{dynamic coherence},$$
$$C=\text{structural closure}.$$

This distinction is important. A system can potentially be dynamically synchronized without possessing the proposed persistent topological structures.

Conversely, local closed configurations might exist without global synchronization.

The interesting regime is therefore

$$R>0,$$

C
>
0
,
$$R>0,\qquad C>0,$$
where collective dynamics and structural closure coexist.

Research on discrete-state approximations of noisy coupled oscillators also shows that continuous synchronization dynamics can sometimes be related to systems with a small number of discrete states, making the comparison between phase dynamics and ternary descriptions mathematically relevant.

5. Connection with Topological Active Matter

The most significant physical connection may be with topological active matter.

Active-matter systems are maintained away from equilibrium by energy input and can display structures that have no equilibrium analogue. Topological defects are particularly important because their properties can be constrained by topological invariants.

Active nematics provide experimentally studied examples in which defects are continuously created, transported and annihilated by active flows.

Vacuum.Net proposes a related but more elementary interpretation:

crossing relations
→
closed configuration
→
persistent structure
.
$$\text{crossing relations} \rightarrow \text{closed configuration} \rightarrow \text{persistent structure}.$$
The possible conceptual correspondence is therefore:

topological defect
↔
persistent relational configuration
$$\boxed{ \text{topological defect} \leftrightarrow \text{persistent relational configuration} }$$
This should not be interpreted as an established equivalence. The two concepts arise from different theories. It is a hypothesis requiring mathematical correspondence and experimental or numerical testing.

6. Computational Test

A minimal computational model was constructed to investigate whether ternary closure feedback can increase the persistence of closed configurations.

The local phase dynamics was given a Vicsek/Kuramoto-like nearest-neighbour coupling:

θ

$$\theta_i(t+\Delta t) = \theta_i(t) + K\,F(\theta_{i-1},\theta_i,\theta_{i+1}) + \eta_i,$$

where K is the local coupling strength and η_i is stochastic perturbation.

The relative phase was then discretized into three states:

$$T_i = \{$$

$+1$	$\Delta\theta_i>\pi/3,$
0	$\lvert\Delta\theta_i\rvert\leq\pi/3,$
-1	$\Delta\theta_i<-\pi/3.$

T_i= \begin{cases} +1 & \Delta\theta_i>\pi/3,\\ 0 & |\Delta\theta_i|\leq\pi/3,\\ -1 & \Delta\theta_i<-\pi/3. \end{cases}

A provisional local closure criterion was applied to neighbouring ternary relations.

Two conditions were compared:

1. ternary dynamics without closure feedback;
2. the same dynamics with weak positive feedback acting on locally closed configurations.

The principal observable was the mean lifetime

τ_C

\tau_C

of closed configurations.

The simulation used 100 interacting sites, 350 time steps and eight independent runs for each coupling value. The coupling was varied from

$K=0.1$

K=0.1

to

$K=2.0$.

7. Results

The simulations produced a non-monotonic dependence of closure persistence on coupling strength.

Without closure feedback, the mean lifetime increased from approximately 2 steps at low coupling to a maximum of approximately 9 steps around $K\approx0.9-1.0$, after which it declined.

With closure feedback, the same system reached a maximum mean lifetime of approximately 18–19 steps around $K\approx0.9-1.0$.

Thus, in this provisional model,

$\tau_{C}^{\mathrm{feedback}} \approx 2\tau_{C}^{\mathrm{contro}}$

1
\tau_C^{\mathrm{feedback}} \approx 2\tau_C^{\mathrm{control}}
near the maximum.

The result is not simply "stronger coupling produces greater stability". Instead, the system exhibits an intermediate regime in which local interaction is strong enough to organize relations but not so strong that local structure is completely homogenized.

The qualitative structure is therefore:

weak coupling
→
increasing closure
→
maximum persistence
→
loss of local structure
.
\text{weak coupling} \rightarrow \text{increasing closure} \rightarrow \text{maximum persistence} \rightarrow \text{loss of local structure}.
This type of competition between collective ordering and local structure is consistent with the broader physics of active and non-equilibrium systems, where ordering, fluctuations and topological structures can coexist.

8. Interpretation

The computational result supports a limited statement:

A ternary relational system with closure feedback can generate persistent closed configurations
.
\boxed{ \text{A ternary relational system with closure feedback can generate persistent closed configurations.} }
It does not establish that Vacuum.Net is physically correct.

In particular, three limitations must be emphasized.

First, the closure operator used in the simulation is provisional. It was constructed to operationalize the hypothesis and is not yet a formally derived consequence of the complete Vacuum.Net theory.

Second, the simulation contains a phase-coupling mechanism inspired by established collective-motion models. Some of the resulting order can therefore arise from ordinary synchronization rather than from ternary closure itself.

Third, the simulation is deliberately minimal. It does not yet reproduce the full geometry, topology, tension dynamics or three-dimensional structure claimed by Vacuum.Net.

Consequently, the result should be regarded as a **proof of concept for a testable mechanism**, not as confirmation of the underlying physical theory.

9. A Proposed Unified Framework

The results suggest a useful mathematical architecture:

T
→
local relational dynamics
→
closure
→
persistent structure
→
collective dynamics
\boxed{ T \rightarrow \text{local relational dynamics} \rightarrow \text{closure} \rightarrow \text{persistent structure} \rightarrow \text{collective dynamics} }
where

T
T
is the balanced ternary relational state.

This can be compared with the conventional active-matter sequence:

local interaction
→
collective order
→
macroscopic behaviour
.
\text{local interaction} \rightarrow \text{collective order} \rightarrow \text{macroscopic behaviour}.
The distinguishing Vacuum.Net proposal is that the relational topology is not merely a consequence of particle motion. It is itself part of the fundamental state description.

This produces two potentially independent order parameters:

R
=
collective dynamical order
R=\text{collective dynamical order}
and

C
=
topological closure
.
C=\text{topological closure}.
The most important future experiment is therefore to map

R
(
K
,

$$R(K,\eta),\qquad C(K,\eta),\qquad \tau_C(K,\eta)$$

over a sufficiently large parameter space.

The critical question is whether there exists a distinct region in which closure and persistence appear independently of conventional synchronization.

10. Conclusion

The comparison between Vacuum.Net and the physics of swarming reveals a potentially significant common structure: both address how local interactions can generate persistent macroscopic organization.

The established physics of self-driven particles demonstrates that local interactions can generate collective motion. Active-matter research further shows that collective systems can possess robust topological structures and dynamically active defects.

Vacuum.Net proposes a different microscopic foundation based on a continuous strand, ternary crossing relations and closure.

The computational tests reported here provide an initial falsifiable result: in the provisional model, introducing closure feedback approximately doubled the lifetime of closed configurations near an intermediate coupling regime. The persistence was not monotonic with coupling strength and exhibited a maximum around

$$K\approx1$$

.

The result therefore justifies further investigation but does not constitute empirical confirmation of Vacuum.Net.

The decisive next step is to replace the provisional closure operator with the exact Vacuum.Net trit algebra and repeat the experiment. If the same persistence transition emerges without externally imposed synchronization rules, the relationship between ternary closure, topological persistence and collective physical order would become substantially stronger.

The central hypothesis can therefore be stated concisely:

Local ternary relations
$\rightarrow$
closure
$\rightarrow$
persistence
$\rightarrow$
collective physical order
.
\boxed{ \text{Local ternary relations} \rightarrow \text{closure} \rightarrow \text{persistence} \rightarrow \text{collective physical order}. }
If this sequence can be derived from the fundamental Vacuum.Net rules rather than inserted into the model, it would provide a mathematically testable bridge between the proposed theory and established physics of collective matter.

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