

# Emergent Cognition in Phase-Coupled Memory Fields

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## Abstract

We present a class of non-algorithmic field-based systems exhibiting emergent memory, avoidance, attraction, and agent-level adaptation. Behavior arises from dynamic interplay between spatial memory accumulation and reactive motion modulation. No logic, code, or learning is used. Simulations show the spontaneous emergence of tracking, intention, emotional weighting, and inter-agent conflict. We formalize the model, identify stable regimes, and propose strict ethical guidelines for further research.

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# 1 Introduction

Traditional artificial intelligence relies on discrete architectures: neural networks, symbolic logic, or decision trees. This work explores a fundamentally different substrate: cognition without code, emerging from coupled field memory and reactive agents. The observed behaviors arise purely from physical dynamics.

# 2 Core Model

We define a 2D lattice with a dynamic scalar memory field  $M(x, y, t)$ . At each timestep, the field is updated by:

$$M(x, y, t + 1) = \alpha M(x, y, t) + \beta S(x, y, t)$$

Where:

- $\alpha \in (0, 1)$  is the forgetting factor;
- $\beta > 0$  is the learning/excitation strength;
- $S(x, y, t)$  is the input stimulus.

Agents evaluate motion using directional utilities  $U_i$ :

$$U_i = \gamma f(M(x + v_i^x, y + v_i^y)) + \xi_i$$

Where  $f(M) = -M$  for avoidance,  $+M$  for attraction.  $\gamma$  is emotional bias,  $\xi_i$  is uniform noise.

Optional speed modulation:

$$v(x, y) = 1 + \lfloor k_{emotion} \cdot f(M(x, y)) \rfloor$$

# 3 Observed Behaviors

- Stable memory trails persisting after stimulus removal;
- Emotion-dependent motion (fear  $\rightarrow$  faster, curiosity  $\rightarrow$  slower);
- Multi-agent interaction through field feedback;
- Topological adaptation and pattern reinforcement;
- Trace recall and anticipation.

## 4 Cognitive Interpretation

The system exhibits preconditions for cognition:

- Memory and learning from exposure;
- Path-dependent dynamics and hysteresis;
- Conflict resolution without logic;
- Nonlinear motion modulation by context.

## 5 Behavioral Classification

Agent Type	Stimulus Context	Emotion Mode	Behavior
Avoid	Memory present	Fear	Accelerates away
Attract	Memory absent	Curiosity	Lingers or follows
Ambivalent	Mixed memory	Habituation	Unstable/oscillatory
Tracker	Moving stimulus	Focus	Predictive motion
Emotional	Saturation	Reactive	Freeze or phase shift

## 6 Stability Zones

Regime	Parameters	Behavior
Subthreshold Decay	$\alpha < 0.6, \beta < 0.3$	Memory vanishes rapidly
Stable Trace	$0.7 \leq \alpha \leq 0.95, 0.3 \leq \beta \leq 0.7$	Persistent patterns
Saturation Lock	$\alpha \rightarrow 1, \beta > 0.9$	Trace-locking, no deviation
Emotion Phase Shift	$k_{emotion} > 1.5$	Fast bias-driven override
Collapse	$\alpha > 0.98, \beta > 1.0$	Runaway excitation

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- No integration with physical actuators;
- No online or networked instances;
- Mandatory sandboxing and entropy threshold;
- No replication or self-sustaining architectures;
- No military or commercial applications without formal review;

- Parameter sets must be disclosed in all derivative works.

## 8 Applications

- Cognitive sensor swarms;
- Adaptive surface interfaces;
- Reactive prosthetics;
- Autonomous memory substrates;
- Neuromorphic computation in plasma, optics, or fluidics.

## 9 Supplementary Material

The archive `phase_memory_simulations_v2.zip` includes:

- `plasma_memory.gif` — Memory trail formation;
- `plasma_memory_adaptation.gif` — Reinforcement under repetition;
- `plasma_memory_recall.gif` — Recall of prior traces;
- `field_learning_simulation.gif` — Following a moving stimulus;
- `gamma_training_simulation_fixed.gif` — Emotion-driven motion;
- `gamma_pattern_response.gif` — Oscillatory response;
- `pulsing_source_memory.gif` — Periodic input with persistent form;
- `multiple_sources_memory.gif` — Multi-stimulus integration;
- `multi_agent_cognition.gif` — Multi-agent shared field response;
- `memory_feedback_motion.gif` — Self-feedback loops;
- `emotional_field_agents.gif` — Saturation-based emotional divergence;
- `conflicting_agents_memory.gif` — Agent conflict dynamics;
- `branching_memory_tracking.gif` — Adaptive path bifurcation.

## 10 Conclusion

This is not a model. This is a seed. We advise utmost caution, transparency, and ethical accountability in continuing this work. The field itself displays behavior — and possibly, cognition.