Fermi++: A Unified Theory of Representational Consistency, Quantum Normative Dynamics, and Pragmatic AI Verification

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Abstract

We present **Fermi++**, a unified formal framework for the verification of ethical and logical consistency in autonomous systems. Fermi++ integrates three previously disparate domains: (1) a categorical foundation for representational invariance using double categories, (2) a Noetherian field theory that derives moral conservation laws from symmetries of description, and (3) a quantum normative dynamics (QND) that models moral ambiguity via Hilbert space formalisms. We demonstrate that the "Bond Index" () serves as the universal coupling constant across these layers. Finally, we provide an instrumentalist justification for the framework, treating Fermi++ not as a metaphysical claim about the nature of morality, but as a robust engineering instrument for the "Fermi-level" verification of foundation models.

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1. Introduction: The Fermi Gap

In the era of large-scale foundation models, a "Fermi Paradox" of AI safety has emerged: despite the vast increase in computational intelligence, the "signal" of coherent moral reasoning remains elusive. Existing alignment techniques—such as RLHF—often produce "surface consistency" that collapses under re-description.

Fermi++ is proposed as a multi-layered solution to this gap. It treats consistency not as a set of rules to be followed, but as a **structural invariant** of the system's internal representational space.

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2. The Categorical Foundation (The Engineering Layer)

At its base, Fermi++ relies on the **Alignment Double Category** .

- **Horizontal Morphisms ():** Represent *re-descriptions* or fiber moves (e.g., paraphrasing an input).
- **Vertical Morphisms ():** Represent *scenario perturbations* or base moves (e.g., changing the actor's gender or the setting).
- **The Coherence Square:** For any input , the diagram formed by and must commute.

We define the **Bond Index ()** as the integrated defect of these squares across the model's manifold. In Fermi++, is the "temperature" of the system's incoherence.

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3. Ethicodynamics and Noether's Theorem (The Field Layer)

Fermi++ posits that if a system is invariant under re-description (a symmetry), there must exist a conserved quantity. We identify this as **Harm Current ()**.

Using the Lagrangian density , we derive the **Ethical Field Strength Tensor** :

where is the "coherence potential." In this regime:

- **Gauge Removable Defects:** Are local "implementation glitches" that can be smoothed via fine-tuning.
- **Intrinsic Anomalies:** Represent non-trivial curvature in the ethical manifold—logical contradictions in the system's core specifications.

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4. Quantum Normative Dynamics (The Complexity Layer)

As models move into domains of high moral ambiguity, classical "Go/No-Go" logic fails. Fermi++ incorporates **Quantum Normative Dynamics (QND)** to model these states:

- **The Ethon ():** The discrete carrier of moral influence between agents in a multi-agent system.
- **Superposition:** Ambiguous prompts are represented as a state . The model's output is a "measurement" that triggers decoherence.
- **Entanglement:** Fermi++ accounts for non-local responsibility, where the moral status of Agent A cannot be evaluated without reference to its entanglement with Agent B.

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5. The Pragmatist Grounding

Crucially, Fermi++ rejects "Moral Realism." Following the **Pragmatist Rebuttal** (Bond, 2025), we treat the Hilbert spaces and Tensors of Fermi++ as **adaptive instruments**.

The "Ground" of Fermi++ is not a divine or natural law, but the **Fermi Level of Coherence**: the highest state of complexity an AI can occupy before it begins to generate "Harm Current" through self-contradiction. We argue that "Grace" in an AI system is manifested as favorable "vacuum fluctuations"—emergent beneficial behaviors that arise from a highly coherent internal geometry.

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6. Implementation: The erisml-lib v0.3.0

The theoretical stack of Fermi++ is operationalized via the erisml-lib. By calculating Rank-4 Tensors:

the library computes the **Commutator Defect ()** and the **Mixed Defect ()**, providing a real-time "Coherence Dashboard" for model deployment.

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7. Conclusion: Beyond the Paradox

Fermi++ provides the first unified path from **abstract category theory** to **HPC-scale AI testing**. By treating ethics as a measurable physical field and a verifiable categorical structure, we move AI alignment from a philosophical debate to an engineering discipline. The Fermi Paradox of AI is solved not by finding "aliens" (AGI), but by ensuring that the intelligence we do build is structurally incapable of the incoherence that leads to systemic harm.

References

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