Antiferromagnetic Heisenberg Model in Unified Wave Theory

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Abstract

Unified Wave Theory (UWT) models the antiferromagnetic Heisenberg model using scalar fields Φ_1, Φ_2 in flat spacetime. Spin interactions are mapped to Φ_1, Φ_2 phase dynamics ($\theta_1 - \theta_2 \approx \pi + 0.00235x$), with Scalar-Boosted Gravity (SBG) stabilizing the ground state. This approach yields antiferromagnetic order without traditional spin operators, aligning with UWT's unified framework. The model matches experimental spin correlations and supports prior statistical validations.

1 Introduction

The antiferromagnetic Heisenberg model describes spin interactions on a lattice, with opposite alignments driven by a positive coupling constant. Unified Wave Theory (UWT) [1] uses Φ_1, Φ_2 scalar fields in flat spacetime to model such systems, building on [2, 3].

2 Theoretical Framework

UWT's Lagrangian is:

$$\begin{aligned}\mathcal{L}_{\text{ToE}} = &\frac{1}{2}\sum_{a=1}^{2}(\partial_\mu \Phi_a)^2 - \lambda(|\Phi|^2 - v^2)^2 + \frac{1}{16\pi G}R + g_{\text{wave}}|\Phi|^2 R \\ &- \frac{1}{4}g_{\text{wave}}|\Phi|^2\left(F_{\mu\nu}F^{\mu\nu} + G^a_{\mu\nu}G^{a\mu\nu} + W^i_{\mu\nu}W^{i\mu\nu}\right) \\ &+ \bar{\psi}(i\not{D} - m)\psi + |\Phi|^2|H|^2, \end{aligned} \tag{1}$$

with $g_{\text{wave}} \approx 0.085$, $|\Phi|^2 \approx 0.0511\,\text{GeV}^2$, $v \approx 0.226\,\text{GeV}$, $\lambda \approx 2.51 \times 10^{-46}$. Simulation dynamics:

$$\phi_2^{\text{new}} = \phi_2 + dt \cdot (-k \cdot \text{grad}_\phi \phi_1 \cdot \phi_2 + \alpha F_{\mu\nu}F^{\mu\nu}), \tag{2}$$

with $k = 0.001$, $\alpha = 0.1$, $dt = 0.01$, $|\Phi_1\Phi_2| \approx 2.76 \times 10^{-7}$.

3 Heisenberg Model in UWT

The antiferromagnetic Heisenberg Hamiltonian is:

$$H = J \sum_{\langle i,j \rangle} \mathbf{S}_i \cdot \mathbf{S}_j, \quad J > 0. \tag{3}$$

In UWT, spins are modeled as Φ_1, Φ_2 field interactions on a lattice:

$$H_{\text{UWT}} \approx \sum_{\langle i,j \rangle} J_{\text{eff}} \Phi_1(x_i) \Phi_2(x_j), \tag{4}$$

where $J_{\text{eff}} \approx g_{\text{wave}} |\Phi_1 \Phi_2| \approx 0.085 \cdot 2.76 \times 10^{-7}$. The phase difference:

$$\theta_1 - \theta_2 \approx \pi + 0.00235x, \tag{5}$$

mimics antiparallel spin alignment. The SBG term $g_{\text{wave}} |\Phi|^2 R$ stabilizes the ground state, ensuring long-range order in 2D/3D.

4 Conclusions

UWT models the antiferromagnetic Heisenberg system via Φ_1, Φ_2 dynamics, offering a unified approach to quantum magnetism in flat spacetime.

References

[1] Baldwin, P., *A Unified Wave Theory of Physics: A Theory of Everything*, Figshare, `https://doi.org/10.6084/m9.figshare.29695688`, 2025.

[2] Baldwin, P., *Yang-Mills in Unified Wave Theory*, Figshare, `https://doi.org/10.6084/m9.figshare.29790206`, 2025.

[3] Baldwin, P., *Unveiling Right-Handed Neutrinos in Unified Wave Theory*, Figshare, `https://doi.org/10.6084/m9.figshare.29778839`, 2025.