Findings Relevant to PWARI-G Cosmology Development

Overview

This document summarizes the results of our most recent atomic-scale simulations and how they may inform the cosmological modeling phase of the PWARI-G (Photon Wave Absorption and Reshaping Interpretation with Gravity) framework. The focus is on gravitationally-bound breathing solitons and the emergence of large-scale structures such as shells, as well as implications for vacuum energy behavior, structure formation, and scalar field evolution in a relativistic context.

Key Results from Atomic Simulations

1. Gravitational Shell Formation from Soliton Cores

- Simulations of four-soliton systems revealed a consistent outward migration of spinor density.
- A stable shell structure formed at a significant distance from the central soliton cluster.
- The shell persisted without decay over hundreds of iterations and appeared to self-organize.
- The shell was visualized clearly in 3D isosurface animations.

Cosmological Insight: This may support a wave-based mechanism for shell structures in cosmology (e.g., cosmic voids, baryon acoustic oscillations). Large-scale vacuum-modulated scalar shells could form as remnants of early-universe soliton-like condensates.

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2. Vacuum Regularization without Divergence

- Simulations were run with gravity, gauge, scalar, and spinor fields all interacting.
- Despite long runtimes, no UV divergence in vacuum energy was observed.
- Energy densities remained finite and bounded due to self-limiting wave interactions.

Cosmological Insight: This supports PWARI-G's claim of natural vacuum energy regularization without renormalization. Such a mechanism could resolve the cosmological constant problem by removing runaway contributions from high-frequency modes.

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3. Wave Detachment and Orbit-Like Behavior

- Spinor fields were observed to gradually migrate into localized shells.
- These shells did not collapse back inward or disperse, hinting at resonance stabilization.
- Tests to confirm whether these are orbital-like behaviors (i.e., bound but spatially detached) are ongoing.

Cosmological Insight: Analogous processes could underlie galactic halo formation or dark matter shells, where the wave nature of mass prevents collapse and mimics gravitational binding without discrete particles.

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4. Shell Formation Timing and Wall Reflection Ambiguity

- Two competing hypotheses emerged:
    1. Shell forms naturally from wave evolution.
    2. Shell forms as a wave reaches the simulation boundary and reflects.
- To distinguish these, longer grids and smaller soliton sizes are being prepared.

Cosmological Insight: Understanding whether shells are intrinsic to breathing soliton dynamics or boundary artifacts is essential. If intrinsic, wave-only matter may naturally explain structure formation in an expanding universe.

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5. Scalar Field Behavior and Potential Coupling to Expansion

- Scalar ϕ field shows stable breathing under gravitational and gauge backreaction.
- Future simulations aim to test if decaying or interacting soliton fields can drive scale factor evolution.

Cosmological Insight: In a Friedmann-Robertson-Walker (FRW) context, such breathing solitons may act as dynamic components of the stress-energy tensor, sourcing expansion or reacceleration without needing dark energy.

Next Steps for Cosmology Work

1. Implement FRW background for scalar field evolution.
2. Investigate large-scale shell emergence from early soliton interactions.
3. Simulate scalar-gauge-spinor interactions in an expanding grid.

4. Compare predicted Hubble parameter evolution to ΛCDM data.
5. Explore wave detachment as an analog to matter-antimatter asymmetry.

Conclusion

The PWARI-G atomic simulations show promising features that may scale up to cosmological regimes. Shell formation, vacuum energy regularization, and stable field interactions all offer potential to reformulate structure formation, expansion dynamics, and early-universe behavior in a deterministic, wave-based model. These findings form a strong foundation for cosmology investigations under the PWARI-G framework.