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The MaxG™ Compression Fields:
A Structural Postulate for Unconventional Superconductivity

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Abstract

We introduce the MaxG™ Compression Field framework, a three-layer structural model for understanding emergent physical phenomena through lossless information collapse. We apply the framework to unconventional superconductors—cuprates, iron pnictides, and twisted bilayer graphene—and postulate that their superconducting behavior arises from shared structural properties that enable maximal compression of electronic degrees of freedom into a coherent quantum phase. This approach reframes superconductivity as a structural phenomenon rather than one governed solely by interaction strength, offering new guidance for materials discovery.

1 Introduction

Despite decades of study, unconventional superconductivity resists a unified microscopic explanation. While BCS theory successfully explains conventional superconductors, materials such as cuprates, iron pnictides, and twisted bilayer graphene exhibit superconductivity that appears sensitive to geometry, dimensionality, and lattice structure. This motivates a framework that foregrounds structure as a primary explanatory axis.

We propose that superconductivity corresponds to maximal compression of microscopic degrees of freedom into a single coherent macroscopic phase. The MaxG™ framework formalizes this intuition via three Compression Fields.

2 The MaxG™ Compression Fields

We define three nested, lossless compression fields that represent the same information at increasing levels of structural collapse.

2.1 CF_0: Enumeration Field (Discrete)

CF_0 consists of explicit microscopic degrees of freedom. In condensed matter systems, this includes individual electrons, lattice sites, spins, and phonon modes. No inference or abstraction is applied; all states are represented explicitly.

2.2 CF_1: Structural Compression Field

CF_1 compresses CF_0 by factoring repetition and relation. Lattice symmetry, dimensional constraints, band topology, and frustration emerge at this level. Composite behaviors collapse inward, while irreducible structures persist. This field governs architectural constraints on dynamics.

2.3 CF_2: Optimal Compression Field

CF_2 compresses structure into governing principles and effective laws. Mean-field descriptions, order parameters, and variational principles reside here. Optimization describes large-scale behavior but does not dictate microscopic updates.

3 Postulate: Superconductivity as Maximal Compression

Postulate 1 (Compression-Coherence Postulate). A material exhibits superconductivity if and only if its CF_1 structure permits lossless compression of electronic degrees of freedom into a single coherent phase under CF_2 optimization.

This reframes superconductivity as a structural collapse rather than solely an energetic instability.

4 Application to Unconventional Superconductors

We examine three classes of materials through the MaxG™ lens.

4.1 Cuprates

Cuprates feature quasi-two-dimensional CuO_2 planes, strong correlations, and lattice frustration. The reduced dimensionality and repeating planar motifs constrain decoherence pathways, enabling robust CF_1 compression despite thermal noise.

4.2 Iron Pnictides

Iron pnictides exhibit multi-band electronic structures with competing orders. Their lattice symmetries and orbital selectivity act as structural bottlenecks, allowing selective collapse of electronic states into a superconducting phase while suppressing full magnetic ordering.

4.3 Twisted Bilayer Graphene

Twisted bilayer graphene produces moiré superlattices and flat bands. Flat bands represent extreme compression: many microscopic states collapse into narrow energy ranges. The moiré geometry engineers CF_1 directly, making superconductivity tunable via twist angle.

5 Corollary: Structural Search Heuristic

If the Compression-Coherence Postulate holds, then candidate superconductors should be sought by optimizing CF_1 properties:

- Reduced dimensionality (2D or quasi-2D systems)
- Structural frustration that suppresses competing orders
- Flat or nearly flat electronic bands
- Defect tolerance that localizes decoherence

This provides a structural heuristic complementary to interaction-based searches.

6 Discussion

The MaxG™ framework does not replace microscopic theory but contextualizes it. CF_0 dynamics generate CF_1 structure, which constrains CF_2 optimization. Superconductivity emerges when all three fields align to permit maximal, lossless compression.

7 Conclusion

We have presented a structural postulate for unconventional superconductivity grounded in the MaxG™ Compression Field framework. By identifying shared compression-enabling features across disparate materials, this approach offers a unifying perspective and practical guidance for future materials discovery.

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