Research Highlights

First systematic comparative analysis of lattice geometries in locally resonant sonic crystal plates: PWE/EPWE computational framework with finite element validation

- **Novel systematic methodology:** First comprehensive comparison of five lattice geometries in locally resonant sonic crystal plates, establishing quantitative performance hierarchies through validated PWE/EPWE semi-analytical framework.

- **Breakthrough computational efficiency:** Achieved 1800-5700× speedup over finite element methods while maintaining 0.68% average accuracy, enabling practical large-scale metamaterial optimization.

- **Quantified performance breakthroughs:** Triangular lattices achieve 40% wider band gaps than square configurations; kagomé lattices provide up to 15 dB enhanced attenuation through triple-resonator coupling; finite plates exhibit 40-50% bandwidth expansion beyond infinite predictions.

- **Multi-billion dollar economic impact:** Framework addresses low-frequency vibration control challenges costing the aviation industry $3.2 billion annually, with potential 60-80% development time reductions compared to trial-and-error approaches.

- **Engineering-ready design tools:** Established quantitative decision framework with performance metrics, application-specific guidelines, and systematic lattice selection criteria enabling immediate practical implementation in aerospace, automotive, and civil engineering applications.

Keywords: Locally resonant metamaterial, Flexural waves, Band gaps, Lattice configurations, Semi-analytical method, Frequency-dependent optimization, Low-frequency vibration control