Tunneling into Regime Shifts:

One-Page Summary

Key Questions Addressed

Theme	Question
Latent Volatility Regimes	Can structurally fragile but directionally biased BTC market states be detected using physics-inspired, unsupervised models?
Signal Construction	Can tunneling scores derived from **Energy-Based Models** capture latent sensitivity to perturbations in a way that anticipates regime transitions?
Trading Application	Can these signals support interpretable, rule-based strategies that consistently outperform BTC buy-and-hold on a risk-adjusted basis?

Conceptual Ideas Proposed

- Rolling window embeddings of standardized BTC returns processed through a two-layer **Energy-Based Model** trained using contrastive noise injection
- Tunneling scores defined via an **exponential decay function** of latent state shifts and corresponding energy changes, inspired by quantum tunneling probabilities
- Entry and exit logic based on low tunneling (fragility) combined with upward drift, signaling high sensitivity with directional pressure; exits occur upon structural stabilization or trend deterioration
- Strategy thresholds selected via exhaustive **in-sample grid search**, prioritizing Sharpe-optimality and behavioral robustness

Key Results

- Backtest delivers a **49.44% CAGR** with Sharpe Ratio of 0.96 over six years of BTC/USD data, using 170 trades averaging 5.6 days each
- Tunneling score extrema (peaks and troughs) align with several known volatility shocks and directional reversals in BTC, suggesting **structural regime sensitivity**
- Ample scope for extension: threshold learning, volatility conditioning, walk-forward testing, and multi-asset generalization

Illustrative Figures and Tables

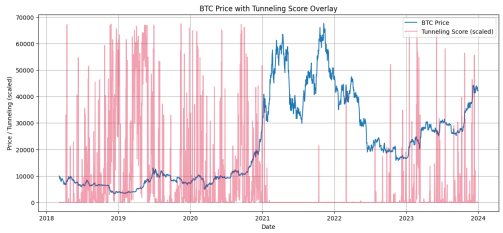

Figure 1 shows BTC closing price with tunneling score overlay, highlighting transitions from structurally fragile to stable regimes

Metric	Value
CAGR	49.44%
Sharpe Ratio	0.96
Max Drawdown	-64.95%
Trades	170

Table 1 shows performance metrics for the tunneling-based strategy on BTC from 2018–2023