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Signatures of Exotic Particles in Ultra-Relativistic Energy Regimes

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Abstract: *In the realm of ultra-relativistic energy regimes, the possibility of producing and detecting exotic particles offers a frontier for probing physics beyond the Standard Model. This paper presents a comprehensive study of characteristic signatures associated with hypothetical particles such as leptoquarks, heavy sterile neutrinos, and supersymmetric candidates within high-energy collision environments. Using simulated datasets and recent experimental results from large-scale particle accelerators—including the LHC-this investigation explores anomaly patterns in kinematic distributions, missing transverse energy, and rare decay channels. Emphasis is placed on discriminating exotic signals from Standard Model backgrounds through advanced statistical techniques and machine learning classifiers. The results highlight key observables and thresholds that could guide future experimental searches and potentially uncover new fundamental constituents of matter. The study also discusses implications for cosmology, including connections to dark matter and early-universe particle interactions*

Keywords: Exotic particles, Ultra-relativistic collisions, Leptoquarks, Heavy sterile neutrinos, Particle accelerators, LHC (Large Hadron Collider)

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