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PROBING ACTIVE GALACTIC NUCLEI VARIABILITY ACROSS TIME AND SPACE WITH LSST

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The Vera C. Rubin Observatory's Legacy Survey of Space and Time (LSST) begins full operations this year, initiating an unprecedented era for time-domain astrophysics. In this light, we present a framework for probing Active Galactic Nuclei (AGN) variability with the Vera C. Rubin Observatory's LSST, grounded in theoretical scaling relations and realized through two novel software tools. Motivated by self-organized criticality (SOC), we aim to characterize both periodic and stochastic components of AGN variability across a broad range of black hole masses and redshifts. The framework includes QhX (Quasar harmonic eXplorer), a nonlinear tool for detecting multi-periodic and emergent structures in red noise, and QNPy (Quasar Neural Process in Python), a probabilistic model that reconstructs

light curves and infers transfer functions across irregular cadences using context-aware latent representations. The Vera C. Rubin Observatory's Legacy Survey of Space and Time (LSST) begins full operations this year, ushering in an unprecedented era for time-domain astrophysics.We systematically evaluate the impact of LSST and ZTF-like cadences on the fidelity of light curve recovery, transfer function inference, and latent space clustering. Performance metrics (negative log likelihood, mean square error) across bands demonstrate robustness to survey strategy, enabling more flexible application of diverse cadence modes without compromising model performance. We further present cadence-informed detectability maps for supermassive black hole binaries, highlighting the regions of orbital parameter space where periodic variability is recoverable across mass ratios and eccentricities. Using QhX, we demonstrate the detection of both real and injected sinusoidal signals and identify off-diagonal structures in frequency-frequency correlation matrices, which reveal signatures of resonances, chirping, and disk–binary coupling. This framework is the cadence-robust analysis pipeline and supports LSST's mission to uncover the multi-scale dynamics of black hole accretion.