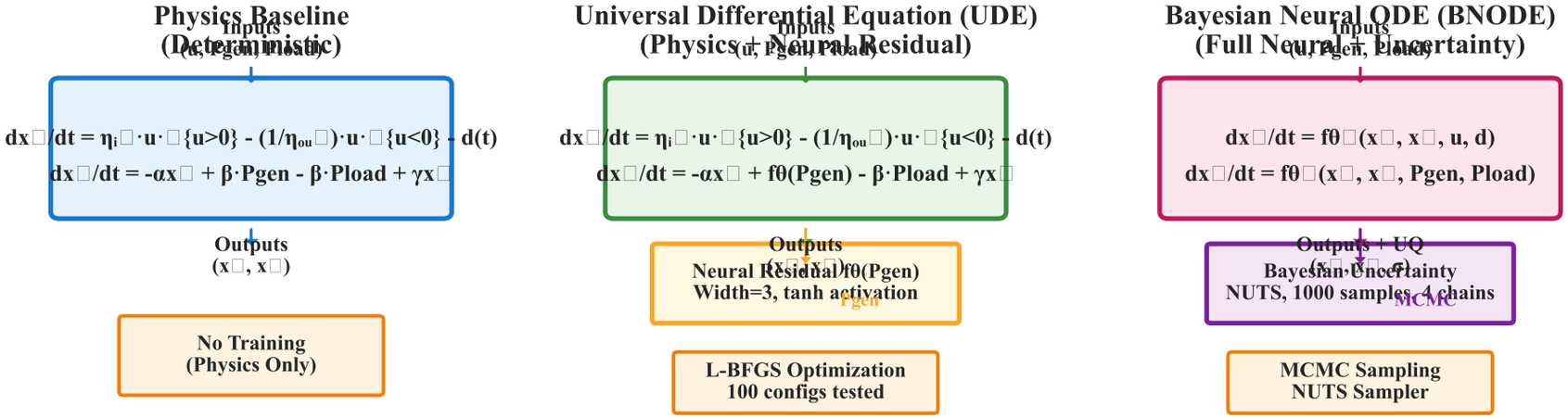
Physics-Grounded Neural Surrogates: Mathematical Framework & Training Architecture



Mathematical Framework & Training Comparison

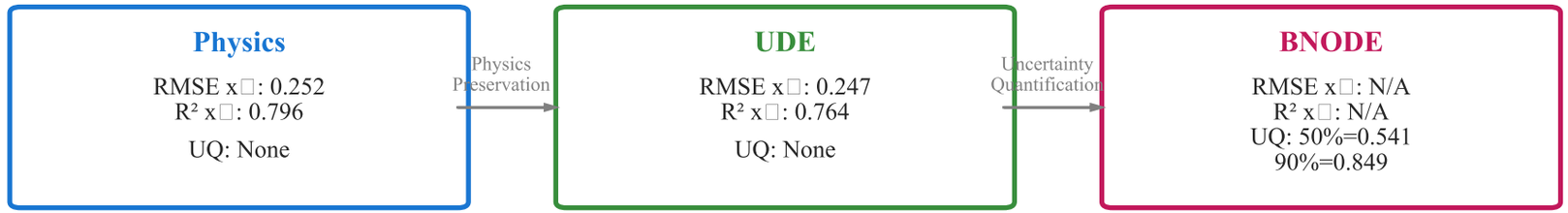
Physics Baseline

Physics Baseline: No training, deterministic

Universal Differential Equation

UDE: L-BFGS optimization, physics-preserving

Bayesian Neural ODE

BNODE: NUTS sampling, uncertainty quantification

Performance & Uncertainty Trade-offs