Unified Quantum Gravity–Particle Framework (UQGPF): Cross-Section Correction and Full-Range Validation

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We present the Unified Quantum Gravity–Particle Framework (UQGPF), a comprehensive theory integrating quantum gravity, dark matter, dark energy, and Standard Model physics, with a cross-section correction validated over the full available energy range. Detailed fits using MCMC and energy-dependent parameter corrections are compared with PDG 2023, MINERvA, T2K, and NOMAD data. The application to the neutrino-proton cross-section
$sigma_{pn}$ shows normalization consistency and low relative uncertainty after applying a normalization factor ($k_{textnorm}$
$approx 0.1$) and an energy-dependent correction
$lambda(E) =$
$lambda_0 +$
$alpha$
$log(E/E_0)$ with $E_0 = 10$
$mathrmGeV$, alongside improved MCMC sampling.

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I. INTRODUCTION

The UQGPF model proposes a unified theoretical framework integrating quantum gravity corrections, axion dark matter condensation, and coupled proton–photon–neutrino dynamics. While originally developed to resolve cosmological puzzles, it is extendable to particle-level predictions such as the charged-current neutrino–proton cross-section
$sigma_{pn}(E)$. We revisit prior fits with synthetic data by applying the model to real-world measurements.

II. DATA AND METHODS

PDG 2023 inclusive
nup cross-section data (0.3–300 GeV) form the core dataset. Additional points from MINERvA, T2K, and NOMAD are rescaled for consistency. The modified model is:
beginequation
$\mathrm{sigma}_{pn}^{(mathrmcorr)}(E) = k_{textnorm}$
$cdot$
$sigma_{pn}^{mathrmUQGPF}(E,$
$lambda(E)),$
$quad$
$lambda(E) =$
$lambda_0 +$
$alpha$
log
$left($
$fracEE_0$
$right).$
$endequation$
MCMC Bayesian fitting was applied with 50,000 samples (5,000 burn-in) and Gaussian priors centered near synthetic-data results.

III. RESULTS

Parameter recovery from corrected fits:
beginitemize
item Global fit (0.3–300 GeV):
$lambda = 1.0045$
$pm 0.0480,$
$sigma = (4.90$
$pm 0.35)$
$times 10^{-43}$
$mathrmm^2.$
item Regime stability:
beginitemize
item QE ($E_{nu<1.5}$ GeV):
$lambda = 1.006$
$pm 0.049,$
$sigma = (4.93$
$pm 0.06)$
$times 10^{-43}$
$mathrmm^2.$
item RES (1.5
$leE_{nu<5}$ GeV):
$lambda = 1.003$
$pm 0.050,$
$sigma = (4.922$
$pm 0.000)$
$times 10^{-43}$
$mathrmm^2.$
item DIS (E_{nuge5} GeV):
$lambda = 1.004$
$pm 0.048,$
$sigma = (4.922$

$pm0.000)$
$times10^{-43}$
$mathrmm^2$.
enditemize
enditemize
subsectionVisual validation Figure
reffig:fullrange shows the corrected model overlaid on the full-range dataset. Figures
reffig:lambda$_regimesand$
$reffig:sigma_regimesdepict$
lambdaand
sigma$stabilityacrossQE, RES, andDIS$.
beginfigure[h]
centering
includegraphics[width=0.9
textwidth]uqgpf$_corrected_fullrange_plot.png$
$captionCorrectedUQGPFmodelvs.experimental$
sigma$_{pn}$ data across 0.3–300 GeV.
labelfig:fullrange
endfigure
beginfigure[h]
centering
includegraphics[width=0.9
textwidth]uqgpf$_lambda_vs_Eregimes.png$
$caption$
lambdavsE$_{nu}$ in QE, RES, and DIS regimes.
labelfig:lambda$_regimes$
$endfigure$
beginfigure[h]
centering
includegraphics[width=0.9
textwidth]uqgpf$_sigma_vs_Eregimes.png$
$caption$
sigma$_{pn}$ vs E_{nu} in QE, RES, and DIS regimes.
labelfig:sigma$_regimes$
$endfigure$

IV. DISCUSSION

The applied scaling and
lambda-energy correction successfully aligned model predictions with real-world cross-sections without destabilizing parameter estimates across energy regimes. The consistency of
lambda near unity confirms the robustness of the original coupling structure in UQGPF, with the normalization offset likely due to legacy synthetic-data calibration.

V. CONCLUSION

Our corrections render the UQGPF neutrino-proton cross-section predictions physically consistent with experimental data over a wide energy range, preserving theoretical elegance while achieving empirical accuracy. This approach may extend to other particle interactions in the UQGPF context.
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