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Fission-Fraction Uncertainties in the Calculation of the Antineutrino Flux from a VVER-1000 Reactor

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The uncertainty associated with reactor fission fractions is an important contribution to precision predictions of the antineutrino flux and to antineutrino-based reactor monitoring. We evaluate the uncertainties and correlations of the fission fractions of ^{235}U, ^{238}U, ^{239}Pu, and ^{241}Pu for a VVER-1000 reactor and propagate them to the calculated electron-antineutrino flux. Burnup-dependent atomic densities and one-group microscopic fission cross sections are obtained with the Serpent Monte Carlo code and combined with BIPR-7A full-core calculations for the 13th fuel cycle of Unit 3 of the Kalinin Nuclear Power Plant. A Monte Carlo procedure is used to vary the nuclide atomic densities and fission cross sections within their adopted uncertainties, providing fission-fraction distributions, standard uncertainties, and correlation coefficients throughout a 500 effective-day fuel cycle. The correlations between the isotope fission fractions evolve significantly with burnup and are explicitly included in the uncertainty propagation. The resulting relative contribution of fission-fraction uncertainties to the antineutrino flux uncertainty increases from approximately 0.25% at the beginning of the cycle to 0.42% at the end. This contribution remains below the uncertainty associated with reactor-antineutrino spectrum models, but is comparable to the characteristic thermal-power uncertainty and should therefore be included in precision VVER-1000 antineutrino-flux calculations.

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