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Numerical Study of Random Noise-Induced Beam Degradation in High Energy Accelerators[1] ARJUN LANDES, RONALD DAVIDSON, HONG QIN, Plasma Physics Laboratory, Princeton University — Random noise caused by small machine errors is an inevitable and potentially significant source of beam degradation in high-energy accelerators. Understanding the detailed effects of such noise on beam quality is critical to evaluating the viability of accelerator design and operation. To this end, we study the dynamics of a single particle under the combined influence of random noise and a quadrupole focusing field. The equation of motion for a beam particle propagating through a sinusoidal quadrupole lattice takes the form of the Mathieu equation. We introduce a small random error into the amplitude of the oscillating term in the Mathieu equation, and solve the resulting dynamical equation numerically using Mathematica, employing stochastic integration techniques, to obtain matched solutions to the perturbed equation of motion. These solutions are then compared with the matched solutions to the standard Mathieu equation to determine the effects of the random noise, e.g., as measured by the increase in mean-square displacement of the particle from the beam axis. Statistical properties of the resulting particle dynamics are measured to assess quantitatively the degree of noise-induced degradation in beam quality.

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