Principles of Nuclear Reactor Physics

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Abstract:
Nuclear reactor physics deals with the physical processes that determine the behaviors of nuclear chain reaction systems and computational methods for the prediction of these processes. Reactor physics or neutronics analysis plays a critical role in reactor design to determine the fuel dimensions and core configuration, fissile and reactivity control requirements, optimum fuel management scheme, heat generation and deposition, fuel composition evolution with burnup, and shielding of ex-core components. The kinetics parameters and reactivity changes for temperature, core geometry, and material density variations are also determined to assure the favorable safety characteristics. The theory and governing equations for reactor physics analysis are well known; Boltzmann equation for neutron and gamma transports and Bateman equation for fuel composition evolution. The Boltzmann equation is a linear integro-differential equation with seven independent variables (three in space, two in angle, one in energy and time), and the Bateman equation is a system of ordinary differential equations. The coefficients of these equations are determined by nuclear data, geometry, and composition. The challenge in neutronics analysis is to determine the solution efficiently by taking into account geometric complexity and complicated energy dependence of nuclear data. In this talk we discuss the principles of nuclear reactor physics, including time-dependent behavior of chain reactions and reactivity feedbacks.