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An effective numerical algorithm for intra-granular fission gas release during non-equilibrium trapping and resolution

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Abstract

Fission gas release and gaseous swelling in nuclear fuel are driven by the transport of fission gas from within the fuel grains to grain boundaries (intra-granular fission gas release). The process involves gas atom diffusion in conjunction with trapping in and resolution from intra-granular bubbles, and is described mathematically by a system of two partial differential equations (PDE). Under the assumption of equilibrium between trapping and resolution (quasi-stationary approximation) the system can be reduced to a single diffusion equation with an effective diffusion coefficient. Numerical solutions used in engineering fuel performance calculations invariably rely on this simplification. First, we investigate the validity of the quasi-stationary approximation compared to the solution of the general system of PDEs. Results demonstrate that the approximation is valid under most conditions of practical interest, but is inadequate to describe intra-granular fission gas release during rapid transients to relatively high temperatures such as postulated reactivity-initiated accidents (RIA). Then,

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