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ONIX: An open-source depletion code with nuclear forensic applications

Nuclear forensic interpretation is an unavoidable stage of the nuclear forensic process: it transforms the analytical results obtained at the stage of characterization into meaningful information useful for formulation of the nuclear forensic findings. As has been demonstrated by the ITWG's exercises CMX-1 and Galaxy Serpent 1 and 4, a capability to understand and use nuclear forensics signatures pertinent to nuclear material irradiated in a reactor is an important part of nuclear forensic interpretation process. It is also often required for operating a national nuclear forensics library [1].

Nuclear depletion codes assist nuclear forensic interpretation by modelling the isotopic evolution of nuclear and non-nuclear materials through neutron irradiation and natural decay. Unfortunately, their proprietary nature and various export control regulations restrict the distribution of these codes, reduce the degree of transparency, and complicate the collaboration between groups from different countries which may be required in case of investigating a cross-border nuclear smuggling incident. The success of these collaborative efforts depends enormously on trust between the different parties involved and the transparency of the technologies used [2].

ONIX (for OpeN IsotopiX) overcomes these limitations by offering a fully open-source depletion software that can model neutron irradiation and natural decays for any materials. Coupling to the open-source Monte Carlo neutron transport code OpenMC allows ONIX to model systems as complex as nuclear reactors [3]. The code uses state-of-the-art algorithms and nuclear data sets. ONIX has been validated and verified through comparison with multiple numerical and experimental benchmarks [4].

ONIX includes the NAX module (for Nuclear Archaeology and forensiX) which has been specifically designed to be a practical numerical tool for technical tasks relevant to nuclear forensics. The NAX module has the following key functionalities:
• Deplete any type of materials from nuclear fuel to structural materials in a nuclear reactor;
• Simulate the depletion of materials with complex irradiation history, e.g. structural materials in reactors spanning multiple fuel cycles;
• Find the best isotopic ratios that can be measured for fluence estimation for a nuclear reactor design and operation history defined by the user;
• Visualize individual nuclides production and destruction paths at any stage of irradiation or decay.

ONIX is currently used by several researchers in various institutions [5], [6], [7], [8]. This paper will present ONIX to the nuclear forensics community and demonstrate different ways to apply it to nuclear forensic science.

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