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Identification of Unknown Nuclear Material

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The identification of unknown nuclear material found undeclared away from designated locations in the nuclear fuel cycle, is an important task in the frame of nuclear forensics. Nuclear forensics is concerned with the timely interception of illicit nuclear material and the determination of its trafficking route from diversion to interception. This could then lead to measures taken in order to combating future diversions of nuclear material away from its designated areas. This work demonstrates an isotopic fingerprinting method to determine the origin of 'unknown'nuclear material with forensic importance, for example from spent nuclear fuel activities.

The origin is determined from the characterisation of the material in terms of its initial enrichment, reactor type and burnup. The characterisation is based on the fact that the composition of spent nuclear fuel in individual nuclides is inherently consistent. A given composition of spent nuclear fuel, being the outcome of its initial composition, reactor type and irradiation history, should characterise uniquely the fuel and hence identify its origin.

The methodology is based on the multivariate statistical technique of factor analysis, complemented by spent fuel isotopic composition information, either simulated using the zero-dimensional depletion computer code ORIGEN or from PIEs such as the databank SFCOMPO. A major source of error in the calculation of the evolution of the fuel in a reactor is the burnup dependence of the cross-sections used. The cross-section libraries should accurately represent a given reactor-fuel system.

The sought characterisation of the unknown material is obtained from the comparison of its U, Pu composition with compositions simulating well known spent fuels from a range of commercial nuclear power stations. Then, the unknown fuel has the same origin as the commercial fuel with which it exhibits the highest similarity in U, Pu composition. The procedure groups together spent fuels from the same reactors, while resolving them well on the basis of burnup and enrichment. Furthermore, it predicts correctly the origin of the 'unknowns'.

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