Towards full physics radiography modelling

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Computer modelling of NDT methods has come a long way and has established itself as in indispensable tool for the NDT engineer. A particular challenge of computer modelling of NDT techniques is to find the right compromise between physical accuracy and computation time, to be useful in the field. The current state of the art in radiographic modelling, as implemented in CIVA and MODERATO, models the main photon-matter interactions in an energy range from roughly 50keV to about 10MeV, including Rayleigh scattering, Compton scattering and pair production. However, at very low and very high energies, other effects such as fluorescence and Bremsstrahlung grow more important and add additional contributions to the final image in terms of scatter, in particular within the detector, but also within the part to be inspected. These additional interactions require the electrons being produced by photoelectric absorption, Compton scattering and pair production to be handled, and the electron cascade with its additional interactions to be treated accordingly. Electrons being the main contributors to the latent image in argentic film radiography, this “true physics approach” has the potential to significantly improve radiographic modelling. However, as the electron mean free path length is extremely small compared to photons, this process is in general considered prohibitively expensive. Or is it? This presentation covers an effort led by CEA and EDF to identify essential photon/electron interactions, and to implement them in a computationally manageable way. As the electron cascade implies a severe penalty on the entire modelling chain, a parallel effort was made to search for efficient variance reduction schemes. The resulting model opens up interesting new applications which were up to now not feasible with photon-only models, in particular for the design and optimisation of filters and intensifying screens for detectors, and for high energy applications.