S5-6: Challenges for radionuclide metrology in the SI

Author: Ryan Fitzgerald

Affiliation of author: Physical Measurement Laboratory, NIST, Gaithersburg, MD, USA

Speaker: Ryan Fitzgerald

Speaker email: ryan.fitzgerald(at)nist.gov

Abstract: This paper will present an overview of the quantum basis for various measurands related to radioactivity, and present the problem of multiple paths to the SI for realizing either the becquerel or mole for radionuclides. Examples will be given for radiochronometry, which can rely on a combination of mass spectrometry and radioactivity measurements to infer the date of origin for a material. Hidden correlations and measurement biases can have detrimental effects on the measurement and uncertainty, yet may be overlooked. Combining these methods requires invoking radionuclide half-lives, which themselves have been measured by some combination of the same methods.

Quantifying the activity of a radionuclide (Bq) can involve traceability to the SI through (e.g.) calorimetry, defined solid angle counting, coincidence counting, or isotope dilution mass spectrometry, depending on the application. Atom counting in particular is only comparable with activity measurements by invoking the radioactive decay law, dependent upon assumptions of stochasticity, and on independent measurement of relevant half-lives. This trinity - activity, number of atoms and half-life of a radionuclide - presents a challenge to contemporary metrology. Related problems arise in nuclear medicine, where complex radionuclide decay schemes are gaining interest for new precision treatments, but pose serious measurement challenges to traditional methods to quantify dose to a patient.

The field is ripe for new techniques, preferably with direct links to the SI base units, as well as more accurate quantum-mechanical calculations of atomic and nuclear transitions that are used in measurement models of increasing complexity for realizing the becquerel. A few promising candidates will be discussed.