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Monte Carlo radiative transfer for neutron star merger simulations

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The kilonova AT 2017gfo that resulted from the merger of two neutron stars has provided new insights into the rapid neutron capture process that is responsible for producing many of the elements heavier than iron. As with supernovae, progress in understanding kilonova spectra can made both by using simple models to connect spectral features to particular elements, as well as by attempting to construct detailed simulations that attempt to capture all of the relevant physics and initial conditions. In the forward modelling approach, we require a theoretical simulations of the merger and ejection physics, r-process nucleosynthesis, radioactive energy deposition, and radiative transfer in order to produce synthetic spectra that can be compared with observations. We plan to calculate synthetic spectra for a three-dimensional merger and r-process nucleosynthesis model using the ARTIS Monte Carlo radiative transfer code. I will describe current progress in extending the code to handle energy deposition from beta- and alpha-decay particles, and the new atomic data required to produce spectral features from transiron elements. I will also discuss challenges around modelling the ionisation state for ejecta in which non-thermal processes are important, which is the case for Type Ia supernovae in their nebular phase, and likely also applies to kilonovae at a few days after the merger.

Presenter: SHINGLES, Luke Jeremy (GSI Helmholtzzentrum für Schwerionenforschung GmbH(GSI))