A mathematical realization of entropy through neutron slowing down

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A classic problem in neutron transport theory is time dependent slowing down in a homogeneous medium. Neutrons (test particles) collide with nuclei (field particles) and lose energy via elastic scattering. In addition, some neutrons are captured and thus represent dissipation. One can analytically solve the neutron slowing down equation, a balance between neutron loss from elastic scattering and absorption and gain from scattering in phase space, in the simple case of uniform cross sections. These solutions provide examples of how entropy tracks mathematics and vice versa through collisions with nuclei. In particular, the solution exhibits oscillations in lethargy (logarithm of the energy), called Placzek transients. The oscillations originate from the continuity of the derivatives of the solution. With increasing number of collisions, the initial sharp discontinuity from the highly singular delta function source become submerged in subsequent higher order derivatives. Hence, with collisions, the solution becomes mathematically smoother. This is a perfect physical example of the mathematical representation of entropy since one begins with a source with no uncertainty (zero entropy) as represented by a delta function; and, with an ever increasing number of collisions, uncertainty is generated (non-zero entropy).

Our focus will be the time dependent case, where the time transient of the scalar flux builds to a steady state. One finds the time dependent solution in an infinite medium through a multigroup formulation coupled to a numerical Laplace transform inversion in time. Included will be consideration of high precision. Specifically, convergence acceleration in the form of the Wynn-epsilon algorithm will generated highly precise numerical solutions in the multigroup form including resonances, where possible. In this way, one can assess the influence of numerical error relative to entropy generation. In addition, test particle dissipation through loss by escape from a slab will be considered in the diffusion approximation.