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How Small Heating of Ultracold Neutrons could be related to the Neutron Lifetime Puzzle

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After cooling and trapping, Ultracold Neutrons (UCNs) reacquire kinetic energy over a relatively long period of time. This process is called Small Heating and it is not yet fully understood. Most intriguingly, this process wears off to some extent.

In 2024 we have proposed a dressed quark model that could explain the Neutron Lifetime Puzzle (NLP). The neutrons in the beam could be in so-far undetected low-energy excited states, while neutrons in the bottle are in the ground state. Neutrons in excited states have more restricted beta decay channels and are thus longer lived than their ground-state versions.

We revisit the Small Heating phenomenon in the light of the excited-state hypothesis. We suppose there is a chain of electromagnetic decays from a neutron in one of the excited states to the ground-state neutron. If this chain is sufficiently long-lived that cold neutrons arrive in the bottle still being in one of the excited states, they may undergo a part of the decay chain inside the bottle. The recoil of each decay event could contribute to the Small Heating of UCNs at an early stage after trapping before wearing off. From the time evolution of the statistical moments of the kinetic energy of UCNs during Small Heating we could infer information on the decay chain and the average photon energy.

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