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Energy accumulation and releases in materials: general expectations and current results for NaI(Tl)

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There are various mechanisms by which energy can be accumulated and stored in materials and later released. Examples include thermally induced luminescence and delayed luminescence/after-luminescence in many materials. Interactions between excitations, defects, or other configurations carrying excess energy can lead to avalanche relaxation or other effects, from small correlations in photon or electron emission during an energy release to self-organization or self-replication effects in systems with energy flow. There is no general theory for these dynamic effects, so one must carefully study and analyze phenomenology in different materials and detectors. We tried to reproduce and further study the energy accumulation and release effects in NaI(Tl) first published by Saint Gobain company - that mild exposure to UV light results in the emission of luminescence pulses at Hz rate, persisting for hours to days after exposure. In the St-Gobain study, these pulses were similar to the response induced by 6-10 keV electrons. We have observed luminescence well over a steady-state background, lasting for days after exposure to UV light. We also observed an increase in luminescence hours after exposure to Co60 source. Our findings differ from St. Gobain's observations: exposure to UV results mainly in an uncorrelated flux of single photons above the background without clear evidence for distinct few-photon events in this photon stream. Exposure to red light suppresses these delayed luminescence effects. Detailed analysis and experimental investigation of uncorrelated delayed light emission and possible correlations/photon bunching at lower "afterglow" intensities are required further to understand our results and the St. Gobain observations. Importantly, environmental factors could modulate excitation quenching and interactions between excitations. Monitoring the average photon flux and searching for correlations/photon bunching, polarization, or directionality of delayed photon emission is required to get more insight into the mechanisms for delayed light production and possible delayed heat/temperature spikes production.
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