MARKUS KLUTE: Welcome back to 8.701. We continue discussion of nuclear decays with gamma decays. We have seen that we can understand nuclear stability or instability. We discussed alpha decays and beta decays. Now after the discussion of the shell model, it is apparent that transition from various nuclear states can be accomplished via the admission of a photon, a gamma ray.

Gamma decays are specifically important in decay chains following an alpha decay or a beta decay where the remnant, the daughter nuclei, is left over in an excited state. Then the de-excitation follows with the admission of a photon.

Practical consequences of this alpha example-- in fission processes where a significant amount of energies can be released with photons, radiotherapy where we try to remove cancer cells or kill cancer cells with gamma rays. Medical imaging works this way. And in general, you can use the emission of those photons to deduce the spin and the parity of excited states.

If you go back very early to this lecture, we discussed the Wu experiment. And also there we used gamma rays in order to reduce the spin and the parity of the states involved.

So nuclear spectroscopy, we haven't discussed the detectors yet. But what's shown here in this picture are two characteristic gamma ray spectra from the case of cobalt and cesium. And if you just focus on the blue line, for example, you see here this peak. This corresponds to the energy of a transition.

But then photons, when they're emitted, they can go through Compton scattering. And they can lose through Compton scattering some of the energy. So you see this tail here.

And then in this tail you see additional peaks. And those additional peaks can come from the fact that a photon can produce an electron-positron pair. And then you see one or two of those pairs in cases where one electron or positron, or both of them, have escaped the detection.

So whenever you look at a nuclear decay, you find spectrums of the sort. And then there are various Compton scattering-- depends obviously on the material around and the composition and also this single and double escape kind of peaks, quite characteristic for the material you're looking at.

So from this, on nuclear spectroscopy you can learn about the sample composition, the element composition of the probe. And interesting effect is the Mössbauer effect. Here again, I'll try to remind you of the discussion of special relativity. We looked at the energy of an emitted and an absorbed photon.

And because in this emission process the leftover nuclei, there has to be a momentum balance. So there is a recoil on the leftover nuclei. So that means it starts moving.

And because it's moving, we have to do a Doppler correction of the energy, meaning that the emitted photon energy is not equal to the energy needed in order to excite the nuclear state again. So this leads then to those energy spectrum. Here, they're the natural widths. And only in this overlapping region here you can reabsorb.

Now the most Mössbauer effect now is a special variation of what I just described. In cases where the nucleon is part of a lattice, the lattice can absorb the recoiling energy. And it leads like to a situation of very, very heavy objects absorbing this recoil.

And in those cases, you can have resonant effects, meaning that this emission line, then absorption lines, they lay over each other quite strongly.