(Foreign language) Knowledge is supreme.

The reason why I call it the story of Raman effect is that, if you have to do justice to Raman effect and Raman spectroscopy, then we have to develop tools of quantum mechanics that we have not studied yet. So to do that, we will need no less than five or six classes. So we… unfortunately we are time bound, like any other course, so we will not be able to do a proper quantum mechanical treatment of Raman spectroscopy, but at least we should have some idea, because as we know this is perhaps the most contribution to science by an Indian from India in modern times. So what we will do is we will… today we will just about… get a sketchy idea of what Raman effect is and what it allows us to do. So Raman discovered many things actually. The most remarkable of which is Raman effect and perhaps you have heard the story that the idea of Raman effect came to him when he was traveling by ship and he noticed that the color of the sky is different from the color of the sea. Now why sky is blue, I think you know it already. Sky is blue because of light scattering and that is the qualitative basis of Rayleigh scattering. Now it's important to understand that he might have got the idea, he might have noticed that the sky is a different view of blue then the sea, but that was not the be all and end all of Raman effect. The real scientific basis of Raman effect was an experiment performed in ISAS by Raman's student Krishnan, who passed, I think the first experiment was done using condensed sunlight. Take sunlight, use appropriate optics so that you get an intense small beam, that was passed through this tube of gas, and he noticed, what he thought was very feeble fluorescence. So initially Raman and Krishnan thought that what we are seeing is fluorescence. But then when we did… they did polarization studies, they understood this cannot be fluorescence. That is what led to Raman effect. So essentially Raman effect, you can explain very qualitatively as in-elastic scattering of light. Elastic scattering of light is Rayleigh effect that is the scattering we see all the time, right. You go to… you see anything, what happens is essentially light falls on the object, gets scattered and that is what you see and there is no change in color, that’s why you see an undistorted picture that Rayleigh effect. In Raman's case what they observed to put it in a very-very simple way is, that they observed an in-elastic scattering of light.
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So when I say inelastic scattering, elastic scattering, does that remind you of something that you have studied perhaps in class 11 in chemistry and perhaps in B.Sc. or undergraduate physics? Yes, Collision theory yes, but something more fundamental, I mean something that is well more celebrated, perhaps across… beyond chemistry? The Compton effect, remember. What is Compton effect? Compton effect, scattering of, is that elastic or inelastic? Yeah right. So Raman effect is sort of Compton effect of photons. So understand nothing, no new discovery is entirely new. If you remember what Newton had said. When did Newton live, I don't remember, which century? 17^{th}, it won't be 18^{th}, perhaps 17^{th} century, something like that, yeah. So even then if you, do you know, one of the most famous quotes of Newton, what he had said, yes. If I have seen further than others, that is because I have stood on the shoulders of giants. We are talking about 17^{th} century, we are now in 21^{st} century, so just imagine how many more giants have come in this period. So any new discovery really is sort of a linear combination of existing knowledge plus a new term. Very rarely do you get something that is absolutely fundamentally different and not at all observed in so many millennium. So Raman effect also has a predecessor you can think in Compton effect. So essentially you have light, falling on your object, let us say frequency is Nu, and the light that is scattered is Nu

+/- some let me write Delta Mu, okay. So this is the change in color. That’s all that is there, okay. So once again coming back to the story of Raman's life, as I said the first experiments were performed using your condensed sunlight. Later on more systemic experiments were performed using mercury vapor lamp. Now the reason why you want to use mercury vapor lamp for Raman spectroscopy is that the output of mercury vapor lamp is something like this. Few… lot intensity versus frequency, there are few frequencies, very-very sharp line at specific frequencies. So it is very easy to have an excitation wavelength Nu0 and +/- Delta Nu of that would be very small. See what we are trying to see is, we are trying to see a difference in frequency, right. So if your incident light itself has a spread of frequencies, in Raman's spectroscopy, you have got a problem. So the best solution at that time was mercury vapor lamp. Raman's spectroscopy really became popular from 1960s onwards. So development of theory and all were done, experiments were done, but widespread use of Raman's spectroscopy only began… only came after 1965 or so, and its popularity is actually… even going up even now, because of another very important invention that happened in 1956, I think. So for Raman's spectroscopy you are trying to measure Delta Nu, so you want your Nu to be devoid of uncertainty as far as possible, you want it to be… okay now you will be able to answer very-very highly monochromatic. So in 1956, around that time lasers were invented by Townes and other people, okay. So when lasers came into existence, that is when Raman effect became really-really useful, because now you could have, if you remember our discussion of laser spectroscopy last week, we had shown you the output of a laser spectrometer, right. What was the accuracy in wave number there, 10 to the power -5 or something, isn't it. So if you want, you can make lasers that are really very highly monochromatic and they are extremely useful for Raman's spectroscopy. There is another thing, with lasers the intensity is also very high, remember, right. So intensity is another… that the Raman signals are usually weak, weaker than what we see in more conventional kinds of spectroscopy. And we will perhaps discuss briefly why. So this is… the intensity of the laser is another… the intensity, monochromaticity, and also remember lasers are usually polarized, laser light is usually polarized, okay. That is another important thing that comes… becomes very important in Raman's spectroscopy. So Raman's spectroscopy really came of age when after the invention of lasers. So what we are doing now essentially is we are continuing with what we had started last week, we are talking about applications of lasers, okay. And another caveat before we go on to the second part of this discussion is, Raman's spectroscopy is different usually from what we have discussed so far in… because it is, what is spectroscopy? Spectroscopy involves transition between two stationary states, isn't it. That was the starting point of our discussion of time dependent perturbation theory, right. In Raman's spectroscopy as we will discuss in a while, the transition is between a stationary state and what is called a virtual state. Again what virtual state is, that is that may not be all that clear to us, even after today's discussion, but we will see how comfortable we can get with that idea. So it is actually called Raman scattering. It is not as if you cannot have Raman scattering involving stationary states, then it is called resonance Raman's, we will come to that very briefly, okay. But this is the introduction to Raman's effect. Next we are going to go on to actual discussion of Raman spectroscopy of dynamic molecules.

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