DJORGOVSKI: Only in the absorption of light going through some thinner dust clouds, until the IRAS satellite in early 1980s, which mapped the sky in near and far infrared and measured thermal emission from dust. Now the dust grains will absorb starlight, get heated to these temperatures of tens of Kelvins, and emit in far infrared. If you're looking at something in emission, that's obviously much easier.

And so there was a lot of important work done. This was all-- a lot of this was done at Caltech. And somebody was saying at the first conference about the results, that Southern California is one of the few places where people may get excited from studying hot dust.

Well, at least if you don't know about the astronomy.

So here is the picture of our galaxy in far-infrared emission from galactic dust. This one is a combination of different channels from the plank satellite, whose job is primarily to measure of cosmic microwave background for cosmology. But before they can do that, they have to remove all of the foreground emission from interstellar medium inside the Milky Way, in order to see the cosmological signal behind it.

And therefore, they need to make really high quality images of where sources of foreground emission in far infrared and millimeter and even radio are, dust being one of them. So obviously there's a galactic plane. You may recognize some of the same big archy features that you've seen in previous maps, and that's because they came from the same supernova explosions But there's a lot of filamentary structure and fluffiness, and so a lot of models that will assume like simple, isolated clouds, are just not really very realistic.

So this is on the biggest scale, the scale of the Milky Way. Now let's put it under a microscope, and there's probably a variety of different kinds of dust grains. But there are on the order of, say, hundreds of nanometers, and we know from studying transmission emission properties that they can contain all the stuff that's common in the universe. There will be ice, water ice, there would be a lot of carbon compounds, and some nitrogen compounds. There will be silicates, those elements were all cooked up in massive stars, and then were expelled by supernovae.

But the size is the important part. What do you know generally about propagation of electromagnetic radiation as it encounters obstacles? For example, light encountering this column.

It doesn't go through, right?

Do radio waves go through this? Can you work, use your cell phone inside this room? Use Wi-Fi? Well, radio waves obviously do.

The reason is that electromagnetic radiation will tend to be reflected or absorbed by the bodies that have size comparable or larger than the wavelength of this radiation. In this case, this would be light. And I'm sorry, I said the opposite. The shorter-- comparably shorter wavelengths will be absorbed or scattered by whatever is doing the scattering, whether it's a big pile of bricks, or just a 100 nanometer chunk of carbon compounds.

And that right away tells you that dust would be much more effective in hiding and scattering shorter wavelengths of light then the longer ones. Which is why those reflection nebulae are blue. Because that's the light that's easier scattered, and this is also why we use infrared astronomy to see through the dust. Because those photons go through without too much trouble.

So let's talk a little bit about the absorption of light, because this is actually a very general treatment, not specific only to the interstellar dust. Let's idealize this, and you may have some source of light intensity at some frequency of nu, and it goes through material. Let's look at the cylinder, just take a chunk. And there's some absorbers in there. Dust grains, say.

So there is an area, there is a length through which it goes, and at the end, you have some decrement. Well, it's going to be decrement, obviously, so d nu is going to be negative.

Well, the number density is denoted usually as N. It's how many particles are per cubic centimeter. But then each of them has a cross section area, which will be, more or less, comparable to its actually geometric cross section. So then, you just simply add up all the area that those photons are likely to encounter. And here it is.

So now what happens? There will be a fraction of radiation that's absorbed. It will be proportional to the fraction of the area that's been blocked by absorbers, like dust grains. And you can express it in the following way.

The change in intensity divided by intensity itself-- so its a relative fraction-- is going to be negative, because light has been removed, not added. It's times some cross section, that's a combination of the density and so on, and the path length. The longer the column, the more likely you are to encounter.

And so this is a very simple differential equation that is trivial to integrate, so it's dx over x, x and then the other one is just integral of x dx. And so it'll be just the path length. Now take the exponential of both sides, and I have that the ratio-- because this was logarithm, right?-- the ratio of the intensity at the end to the intensity at the beginning is proportional to the exponential function, with a negative exponent, is linearly proportional to the length.

So as radiation goes through some absorbing medium, its intensity declines exponentially. And this is why dust clouds are so effective in hiding parts of the Milky Way behind us. Now this exact same treatment would apply to, say, plasma inside stars, except this would be a whole different set of wavelengths, and so on.

So astronomers like to express this in the following way. This is a so-called extinction curve, which gives you optical depth, which is how many e-folding the lengths of extinction you look through is a function of wave number, 1 over wavelength. And so the infrared is on the left, ultraviolet is on the right. And you can see that the infrared, well, those photons tend to go through, no problem. As you go to shorter wavelengths, the dust is more effective in absorbing, and if it wasn't for this little bump that is due to silicate dust grains, it would be more or less linear proportion of this logarithmic decrement.