Optical Methods for Solid and Fluid Mechanics

Prof. Aloke Kumar and Koushik Viswanathan
Department of Mechanical Engineering
Indian Institute of Science – Bangalore

Lecture - 12
Light Matter Interaction II (Lab Demostration)

Hello and welcome. So, in the first part of today's lecture you went into the lab and with the help of Naveen Abhinit you saw the demonstration of imaging of a macro scale object in the lab with the help of a DSLR camera and a lens combination. Now what we wanted to illustrate is the issue of imaging and how the lenses and the camera settings influence the images.

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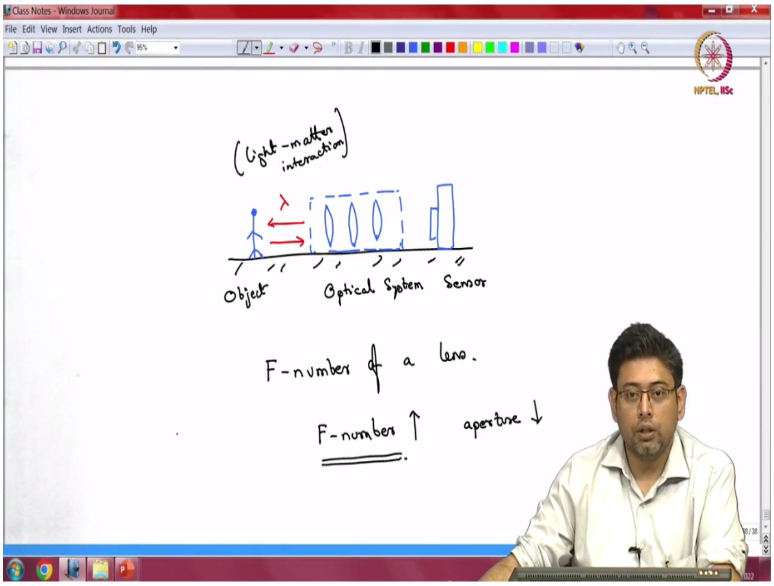

Now you might recall that we had discussed the generic imaging in any system where let us say I draw my object I am just going to make a stick shape here and you have an optical system; now the optical system can be various. It often consists of lenses. Now, this optical system can consist of a lens it can be a single thin lens, it could be a combination of different type of lenses.

In the lab demonstration that you saw all the three lenses are actually combination of different type of lenses that are put together so it is a compound lens system and you have the ability to control sometimes the focal length, for example, in the zoom lens you have the ability to control the focal length of the lens by varying let us say by turning a knob in that case then you have a camera right or a recording or a sensor which records the images.

So, there is one more thing that is here which we will illustrate which is the light falling on the object and the light being received by the optical system. So, as an abstraction I can say that this entire thing consists of an object which needs to be imaged an optical system, a sensor and some form of light and matter interaction. Now the optical system can be various, it can be a lens.

It can be a thin lens, it can be a single thin lens, it could be many lenses put together, it need not even be a lens all the time, for example, there are telescopes which use mirrors. So, the optical system here can be various and it depends on the particular circumstance of the situation. The sensor here can be a camera that you are accustomed to or it could be some other sensor as well.

But usually here most of the time what we have is a camera of some sort and then obviously you have the object and you have some sort of light matter interaction. So, some sort of light is falling on my object and this light is being some sort of a electromagnetic radiation is being received by the optical system and process through it and finally being recorded by my sensor.

Now in the optical system that we have you can have a various range of choices depending on the particular circumstance. In the lab today we are going to look at macroscopic imaging using one of the most commonly used combinations which is that of a DSLR camera and a lens that goes along with it. The big advantage of a DSLR camera is that it usually allows you to swap different type of lenses.

So, you can take a prime lens that Naveen is going to show you in the video. He has already shown you in the video a prime lens or you can swap out and have a zoom lens instead. So, this gives you a significant advantage, you can also use different adapters and even have microscopic lenses attached on to a DSLR camera body. So, it affords you a very strong ability to change between different setups.

Now, in an optical system for example in the DSLR lens and camera combination that we are we have shown you in the lab. The lens is such that the sensor or the camera body can be used to control some of the settings. So, for example, if you wanted a different side of aperture you can input the kind of aperture you want in the sensor electronics and the system will correspondingly change it in the optical system.

Now here I want to point out something that although this is one of the most widely used systems for large scale imaging it is not the only one. Here the lens and the camera body are put together that need not always be the case. For example in a microscope in a regular commercial microscope usually there will be a separate port for a camera and there will be a different port for the lens and there will be separated by a largest distance.

So, just because in this particular demonstration you are seeing a lens and a camera combination together do not think that this is the only possible way, this is one of the ways right. So, in your own experiment whatever the need be you will have to adapt like that. Now one of the things we are going to show you, we have shown you in the lab is to change the f number of a lens.

Now the f number is related to our aperture of a system. So as my f number increases in this system my aperture actually decreases. So, this is a number that I can control using my system and effectively what it is doing in the optical system is it is controlling my aperture. So, you cannot set the f number to any arbitrary value there are a set of values that you have access to in a DSLR lens.

And a sensor combination and when you do that the aperture becomes a certain fixed value. So, let me do one more thing I have what I have done is whatever you saw in the lab I have made a PPT out of it and I will just quickly go over all the things and highlight some of the key issues there so that we are able to understand everything better.

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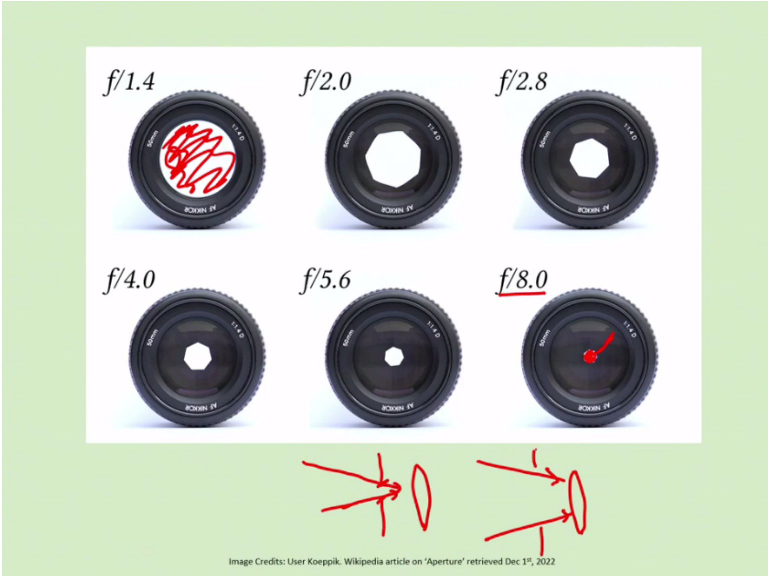

So, in the lab session one of the things Naveen is going to show you is the effect of aperture and this image which is not mine and I have given the image credits at the bottom here. The effect of different f numbers is shown so as you can see this is f 1.4 and this is f 8.0 and it is sort of obvious what is happening. This is the area through which light can pass at f 1.4 and corresponding here this is the area over which light can pass at an f number of 8.

So, this f by is this means this is the f number that is being used. So, this is something that can be controlled this is your aperture right here and this aperture is somewhere inside the lens and it is not a front aperture or a back aperture it is some somewhere inside and you can control it in our demonstration it is somewhere inside and you can control this using the camera body. So, when we started the imaging.

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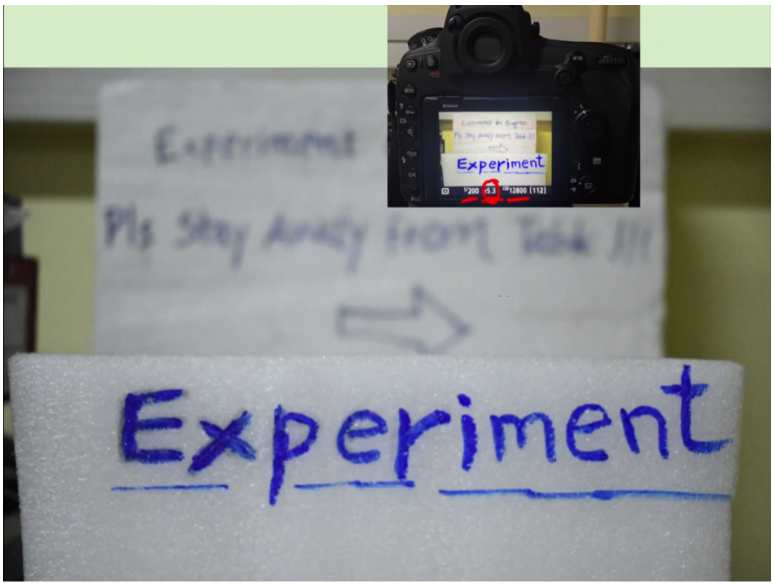

This is the first image and we can see that the f number here is f 5.3. So, when you input the number of 5.3 this is again a number that you can control from the camera body, the lens is such that it is motorized. So, the coupling is such that the moment you input this number the camera forces the lens to operate at f 5.3 and this is the image that you get. This is the object that was placed in front.

You have this bright blue let us say experiment that are visible and in the back there is also some words, but you can see they are very hazy, they are not visible. The light is enough it is not a question of exposure time although exposure time here is also mentioned 1 by 200 and the ISO is also mentioned, but it is not an issue of the light. It is how at this particular point you are not able to image the letters in the back. So, we will see how this problem was addressed.

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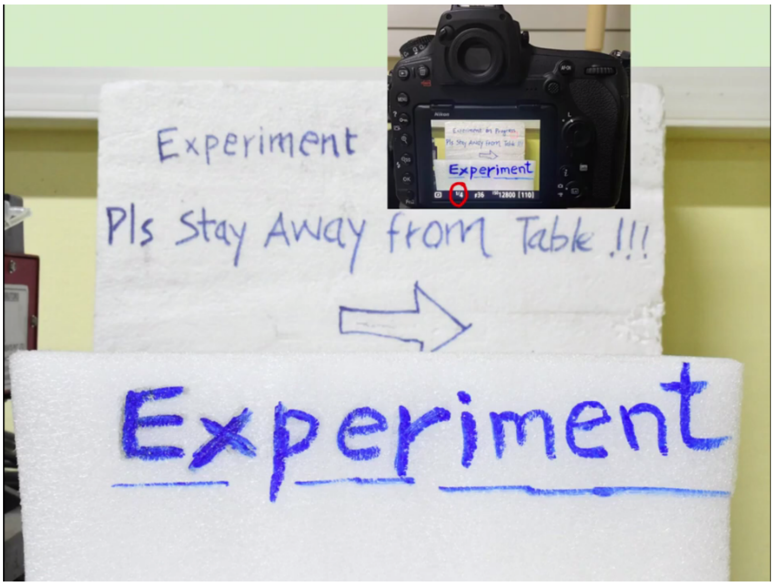

Now this is the same experiment repeated at a different f number. So, you can see this is f 36 and you can see the word experiment written here and you can also read experiment please stay away from the table at the back and you can also see this arrow and both these set of letters now has become very, very clear in this particular image, but image also has become very dark compared to the last one is not it.

So, this is a very bright image the object in the behind is not very visible. In this particular case as you just change only the f number and no other variable was changed both the letters in the back and the front are now visible, but the entire image has become very, very dark. So, to address this what Naveen and Abhinit do is to change your exposure time. So, now the exposure time is up to 1 by 4 seconds earlier it is 1 by 200 seconds.

So, the moment the exposure time is changed the image becomes bright because you have Latin light for 1 by 4 seconds instead of 1 by 200 seconds and now everything here is bright and clearly visible. So, you can see that this is the same lens nothing has been changed except for the aperture. So, why does this happen? Well, a higher aperture essentially starts as we saw here let me go back to this.

So, at a very high aperture values you are basically constraining the amount of light. So, if you have a lens you are constricting the light to enter through the very small cone and this small gap that you have this is a mechanical gap. This small gap now starts to act more like a pinhole. As it acts more like a pinhole everything starts to come into focus. At a lower f numbers you have a larger cone of light that is entering into my system.

So, the imaging is changed just by controlling not the lenses or not the not the lens type or even the placing of the lens is with respect to each other, but simply by the use of this aperture.

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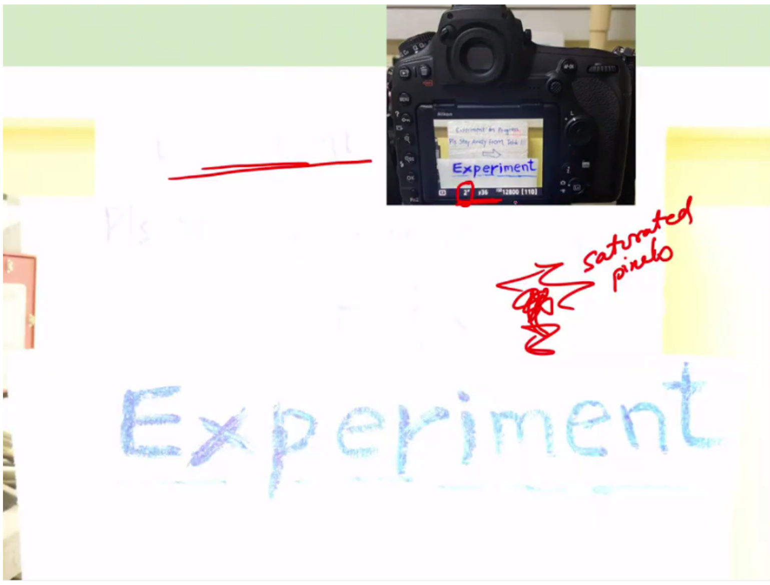

And here this is a demonstration of what happens when you let too much light in. So, now everything else is remaining constant, the exposure time has now been increased to 2 seconds and you can see that this as an overexposed image it is so bright. So, if you took this into image J or some other software which can read the values you will see that all these places which are very bright all these places they will be all saturated.

So, these will be saturated pixels all here. Obviously almost all of the picture is saturated except for a few places I will just scribble over here just to sort of show you one of the locations and now it is saturated enough that this portion is not even readable. So, now in order to correct the system, but keep these two numbers constant what Naveen and Abhinit do is they now use a smaller ISO.

So, this value now also controls the amount of value that is read by your pixel per photon and you can see that by decreasing this number to 1,000 earlier it was 12, 800 which is a very large number. Now it is down to a 1,000 you suddenly have everything back not only in focus, but the image is not excessively bright. So, this shows you how you can control different variables in the lab using settings on your camera.

Obviously we have not been able to show you all different combinations that is not the intent. The intent here is to show you one particular combination and which is a very widely used combination of a DSLR camera and its corresponding lenses and you can experiment with others if you want to. This camera again I am going to repeat is a color camera. This is often I have mentioned it before often scientific cameras are monochrome where you might have to change the gain or etcetera in a slightly different way.

So, I hope in this lab session you were able to get a feel of what happens in this optical system and how variation in the optical system causes a significant change in the image that is recorded by a sensor and that was the purpose of this lab demonstration. So, thank you very much and I will see you in the next class.