Infrared Photography by Ken

Introduction

I spoke with Dan at LDP LLC and MaxMax.com on Jan. 10, 2020. I bought all my IR filters from him 15 years ago and he graciously gave me verbal permission to use his charts. Thank you Dan. If you want to play around with IR photography please contact him at (201) 505 - 1566. Let him know that you are from Silver Spring Camera Club please.

All the other graphics I believe are from Wikipedia.

I had written a good bit of this before finding a book, Infrared Photography Handbook by Laurie White. She has done a much better job than I in explaining all the different parts, 100 plus pages worth, however mostly as it relates to film. When you see Blue text, that is an indication of information gleaned from her book. Green Text indicates what I was already aware of but had left out of my original article that she has caused me to include.

Background:

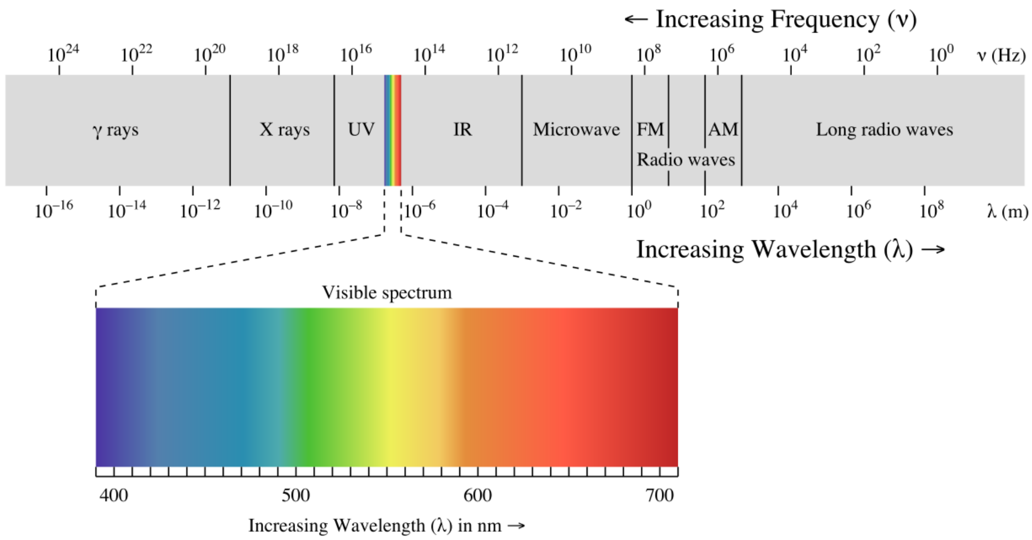
Back in 2005, I purchased a Nikon D70 camera. It was my first digital camera. Shortly after purchasing it (six months to a year) I decided I wanted to try taking infrared images. I am drawn to it by the high contrast of dark skies and illuminated objects. I called up Dan (mentioned above first paragraph) and he sold me some filters. The first problem was the very long exposures. This was because the infrared filter was blocking all the visible light, and the OEM IR cut filter over the sensor was blocking most of the infrared light. At the time, I had found on the internet a step by step word and picture tutorial on how to "break", or I mean to say, convert your Nikon D70 by removing the IR cut filter and installing another filter. Wanting the flexibility to shoot visible and IR with one camera, I called Dan back up and he very reluctantly sold me a clear piece of glass that was an exact shape (height, width, and thickness) of the IR cut filter (see picture on page four for both). I followed the instructions step by step and replaced the IR cut filter with the clear glass. The operation was a success the second time. I had failed to shove a cable far enough into the socket on the first reassembly. Now by changing the filter on the front, I could do visible, infrared, and a little ultraviolet. Almost all of the images (visible and infrared) in this article were shot with that camera. It is still functioning today.

To get black and white images out of the camera, one needs to shoot out of focus some nice luscious green grass in bright sun to set a manual white balance.

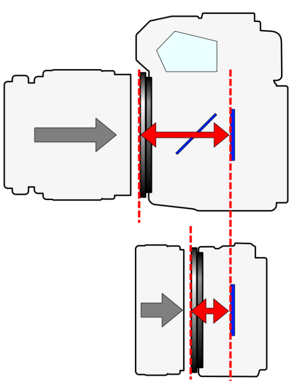
The best time to shoot infrared images is on a "low" humidity day when the sky appears a nice brilliant blue with the sun high overhead. That would be mid-day.

For formatting purposes the article will start on the next page.

What is photography as we typically practice it? It is the collection of light photons that are in the visible part of the electromagnetic spectrum.



To break this down to the basic parts we have a lens, regardless of how fancy, expensive, or simple and cheap, such as a tiny hole (pin hole camera).



A box. Fixed lens cameras still contain a box. The box can be defined by the flange distance for SLR cameras with interchangeable lenses. This is the distance that is between the lens mount and the sensor.

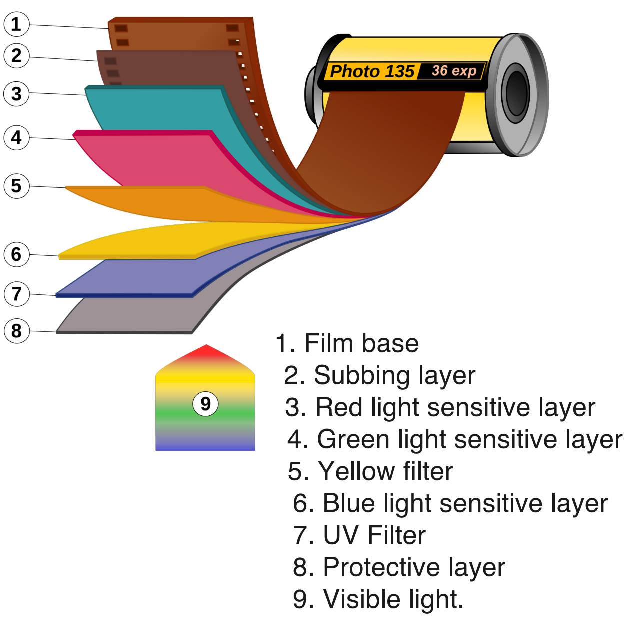
Nikon F mount Flange Distance is 46.5 mm.

Canon EF mount Flange Distance is 44 mm.

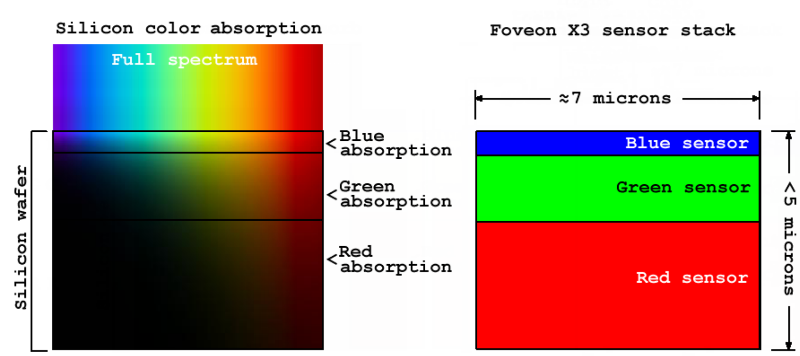
This is the reason that a Nikon lens with the use of an adapter can be used on a Canon camera and still focus to infinity but not vice versa.

And last is the sensor.

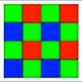
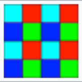
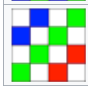
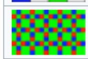
Film:



Foveon Sensor

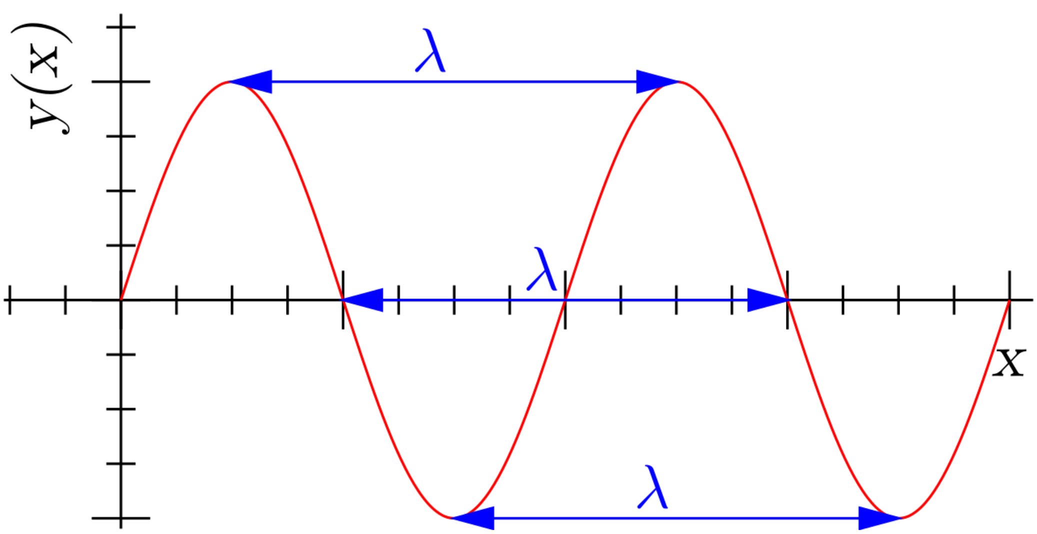


List of color filter arrays [edit]

Image	Name	Description	Pattern size (pixels)
	Bayer filter	Very common RGB filter. With one blue, one red, and two green.	2×2
	RGBE filter	Bayer-like with one of the green filters modified to "emerald"; used in a few Sony cameras.	2×2
	CYYM filter	One cyan, two yellow, and one magenta; used in a few cameras of Kodak.	2×2
	CYGM filter	One cyan, one yellow, one green, and one magenta; used in a few cameras.	2×2
	RGBW Bayer	Traditional RGBW similar to Bayer and RGBE patterns.	2×2
	RGBW #1		4×4
	RGBW #2	Three example RGBW filters from Kodak, with 50% white. (*See Bayer filter#Modifications*)	
	RGBW #3		2×4
	X-Trans	Fujifilm-specific RGB matrix filter, with a large pattern, studied for diminishing Moiré effect.	6×6

And the most important part is a photon collector, whether it be a photographic film, or a semiconductor sensor of some sort. As can be seen in the table below (next page) from Wikipedia, each color has some unique characteristic based partly on wavelength. By making the photon collector sensitive to a specific characteristic, for example blue light by putting a blue filter in front of it and preventing the longer wavelengths of green and red from reaching the photon collection device, it will only see blue light. The Bayer sensor does this. See "List of color filter arrays" above.

The length of the wave from crest to crest determines the color characteristic of the light. Visible light is measured in nanometers (nm), which is a millionth of a millimeter. The visible spectrum is approximately from 380nm to 730nm.



Color	Wavelength	Frequency	Photon energy
Violet	380–450 nm	668–789 THz	2.75–3.26 eV
Blue	450–495 nm	606–668 THz	2.50–2.75 eV
Green	495–570 nm	526–606 THz	2.17–2.50 eV
Yellow	570–590 nm	508–526 THz	2.10–2.17 eV
Orange	590–620 nm	484–508 THz	2.00–2.10 eV
Red	620–750 nm	400–484 THz	1.65–2.00 eV

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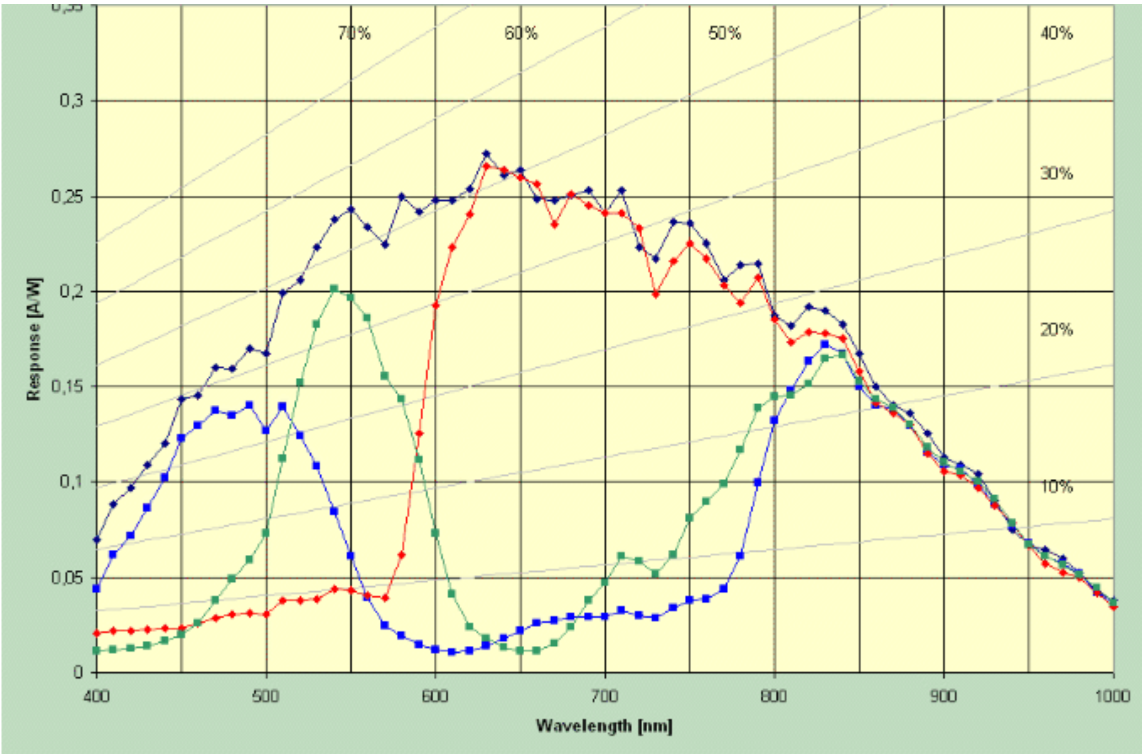
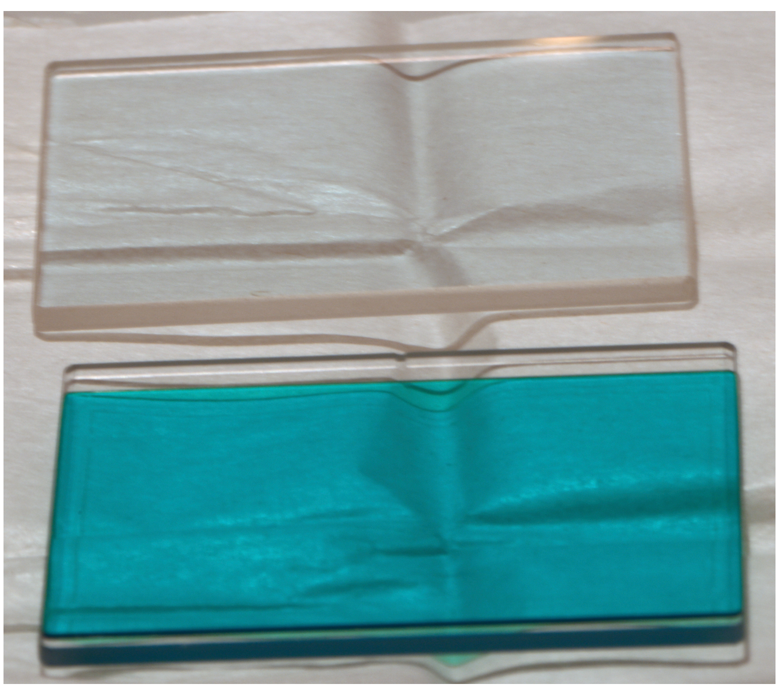


Here is a CCD response curve (courtesy of Dan at LDP LLC and MaxMax.com).

Let us take a quick look at the graph above. As can be seen in the graph that the CCD is more sensitive to red and beyond the considered end of the visible spectrum at 720nm or 730nm (a longer wave length) than that of the blue or green channels in sensitivity. This is the reason manufacturers put a bluish green filter (see bottom of page) in front of the sensor to block IR light. This filter is known as an IR cut filter. The purpose of this filter is to block light that is not part of the visible spectrum from reaching the sensor.

Also notice how at approximately 830nm wavelength and above the blue, green, and red channels contribute approximately equal amounts of information not based on color but luminosity (Response). Remember, blue and green color as we know them occur at wavelengths of less than 650nm.

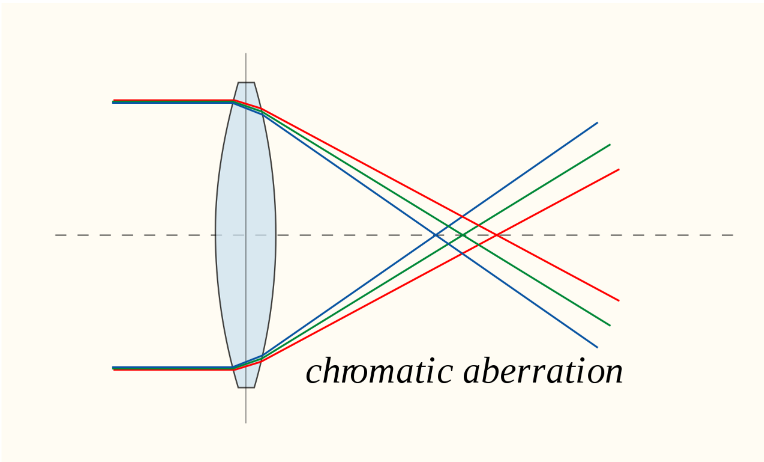


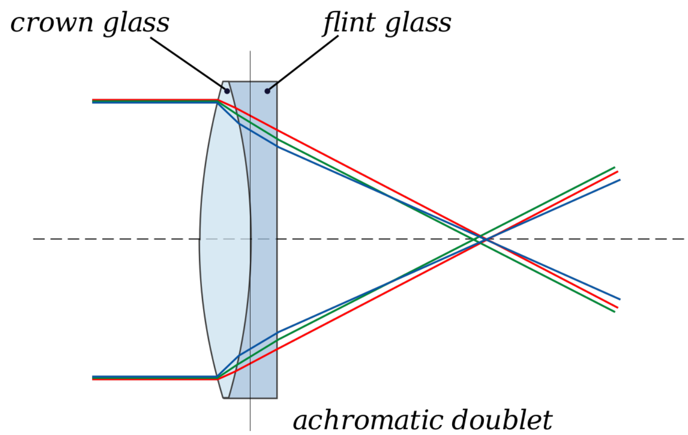
Extra piece of clear glass in case I broke or had issues with the first.

You can also see refraction taking place in the glass. That is the reason one has to replace with an identically thick piece.

IR cut filter from my Nikon D70. Note the cyan tint.

Waves of different lengths behave differently when passing through a lens. The shorter wavelengths focus closer while the longer wavelengths focus at a point farther away as illustrated below. There should be another set of lines to show that the infrared focuses to the right of the red lines. Manufacturers of lenses have addressed this issue by lens design and creating exotic types of glass.





Lenses that have "achromatic" in the name indicate efforts have been taken to get all the colors (wavelengths) to focus at approximately the same point.

Some lenses even have markings for where the infrared focus is, as infrared light does not focus the same as visible light.

Photography is all about the collection of photons reflected off of an object. The quantity of photons determines what areas will be bright or dark for black and white photography. For color photography, selected wavelengths of photons are collected by collectors that are sensitive to certain specific wavelengths. The mixing and matching of red, blue, and green photons from their respective collectors allows for a wide spectrum of colors in our images. Infrared photography is no different except a different part of the light spectrum is used to create black and white images that is not part of what the human eye can see. The near infrared spectrum ranges from approximately 730 nm to 1200 nm. If you feel warmth, you are in the far infrared part of the spectrum.

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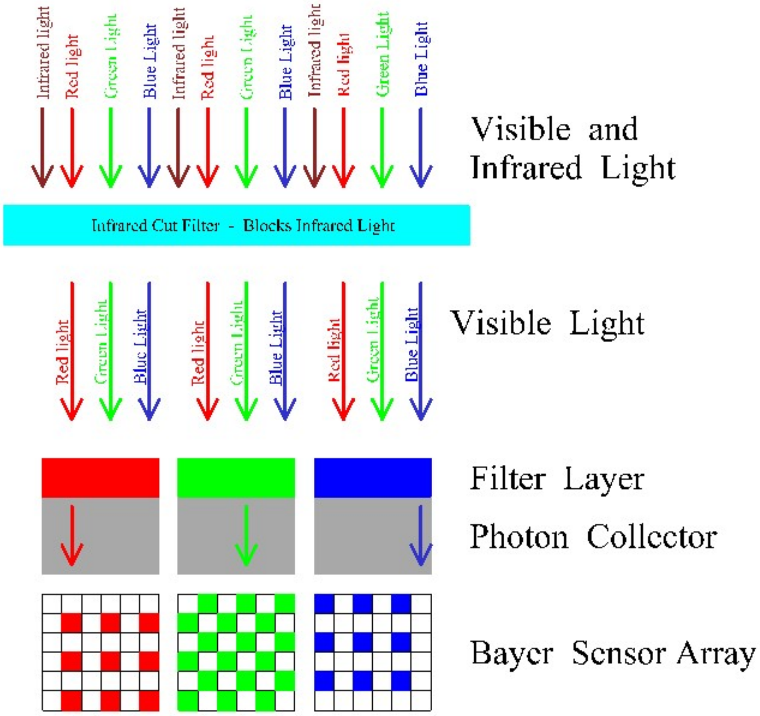
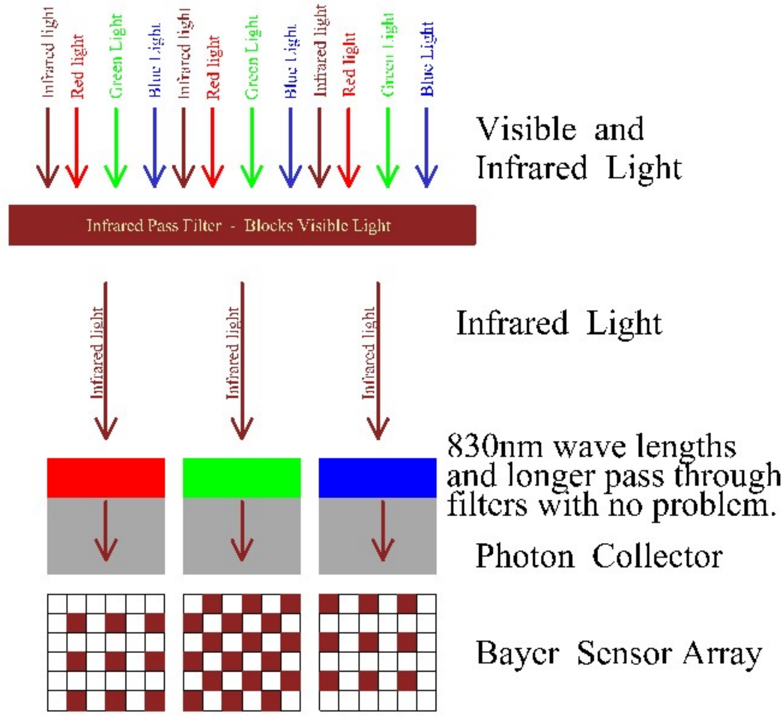




I am going to slightly over simplify an example. So if we were taking a picture of a very red tomato hanging in our garden on a green stalk against a blue sky, what is happening? The tomato is absorbing all the blue and green light while reflecting the red. The Bayer sensor in the camera with green and blue filters, block the red light from the green and blue photon collectors. The photon collectors with a red filter let the red reflected light in to the red photon collectors.

The same principle applies to the green stalk. The green stalk is absorbing the red and blue light while reflecting green light. The Bayer sensor in the camera with red and blue filters, block the green light from the red and blue photon collectors. The photon collectors with a green filter let the green reflected light in to the green photon collectors.

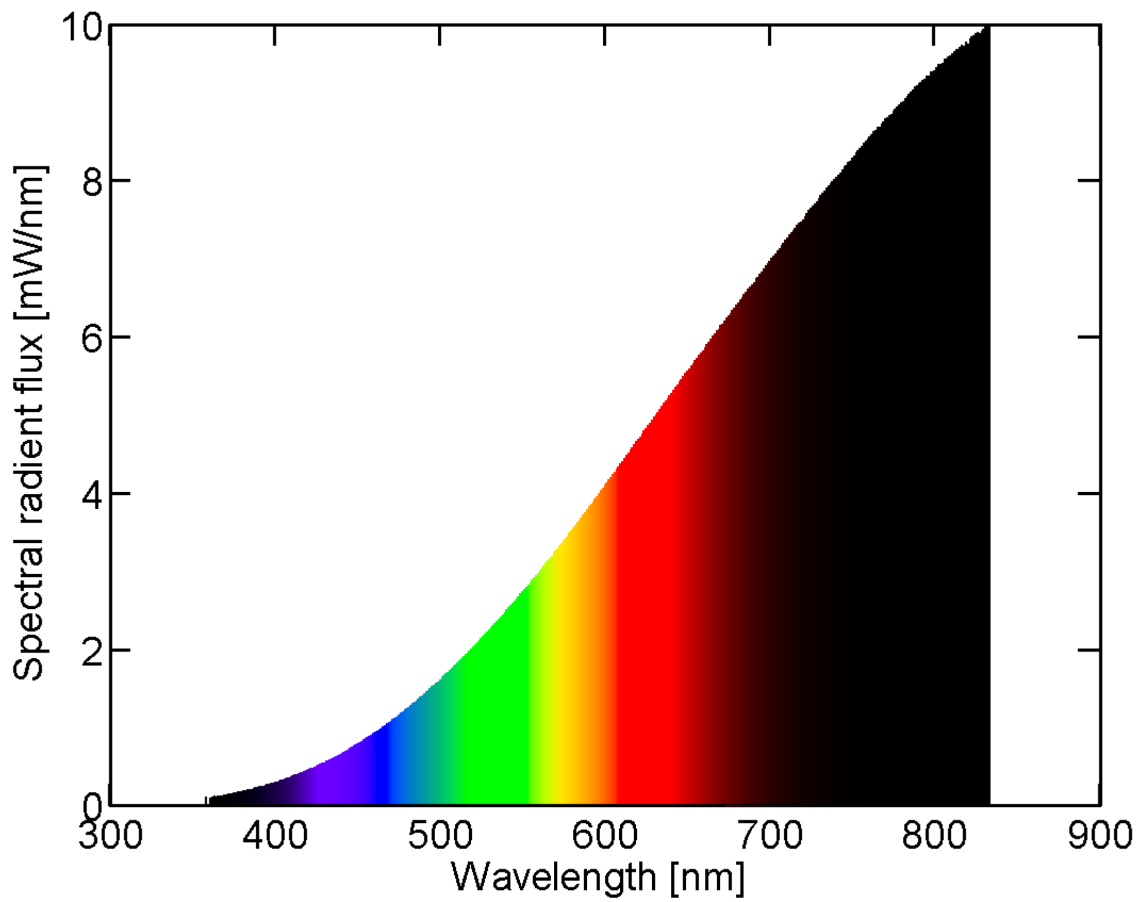
The blue sky is slightly different. The atmosphere around our planet causes some of the blue photons and those of shorter wavelength (ultraviolet) to be scattered and absorbed in the atmosphere during the middle of the day, causing the sky to appear blue. (As the wavelength increases to red and infrared, the light from the sun passing through the atmosphere is less inhibited. Red (or some variation of it such as yellow, orange or pink) light, which is a longer wavelength, as we know from watching sunrises or sunsets, passes through the atmosphere better than all the colors before it.) The Bayer sensor in the camera with red and green filters blocks the blue light from the red and green photon collectors. The photon collectors with a blue filter let the blue reflected light in to the blue photon collectors.

What is the light?

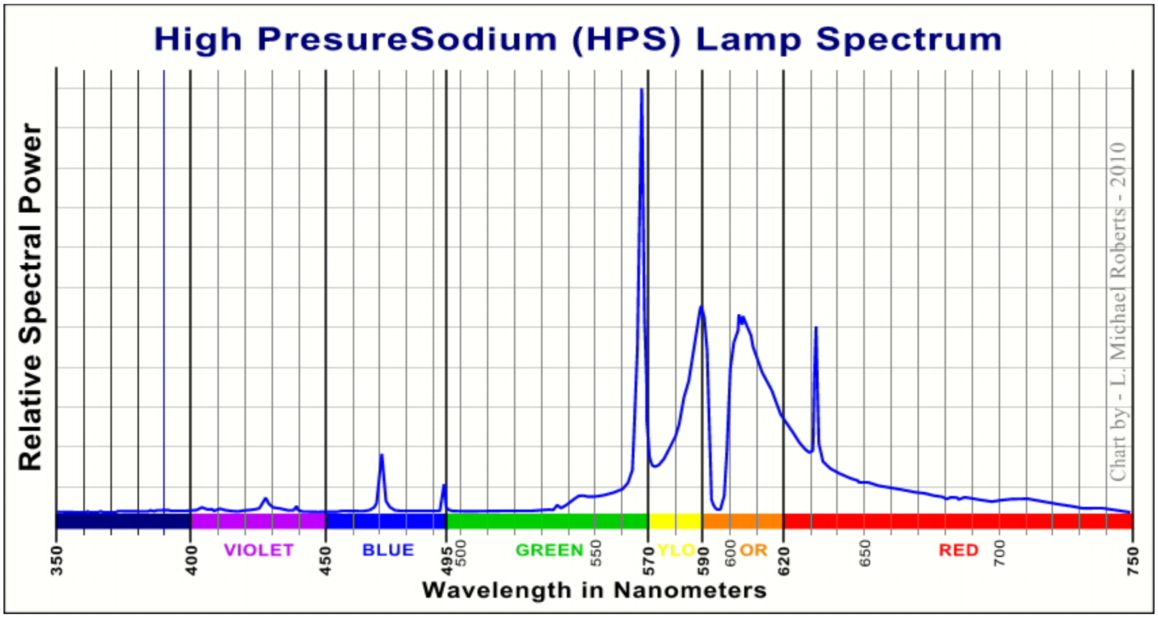
One must know what the light source is. If one wanted to take a picture with red light, one would not pick a green or blue light. Infrared is no different. One must pick a light source that will provide infrared light. The mid-day sun is an excellent choice on a clear day. An incandescent bulb is also a good choice as eighty to ninety percent of the energy goes to heat and only 10 to 20 percent comes out as visible light that we can see.

A LED that is in the visible spectrum is a very poor choice, as it does not provide any appreciable amount of near infrared light. (Maybe a little in the far infrared in the form of heat from the electronics, but not in the near infrared spectrum.) Any of the traditional mercury or sodium vapor type bulbs, fluorescent tubes, compact fluorescent, and LED are bad choices.

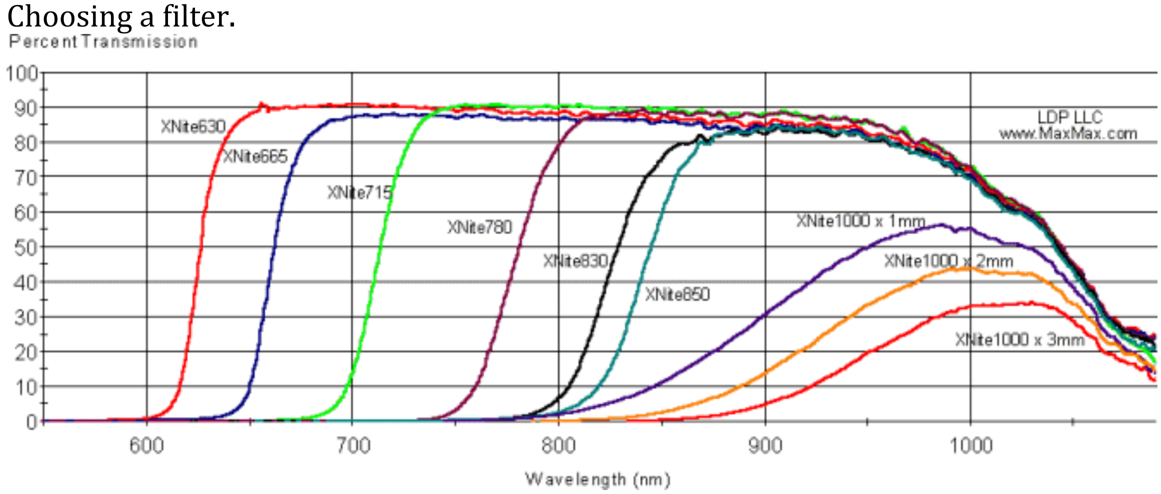
Below is a partial chart of the spectrum of a 25-watt bulb. We all know that incandescent bulbs run hot, so obviously the test stopped outside the visible spectrum but is not the complete spectrum that the bulb gives off.   Another source indicates a bell curve peaking around 900 to 1000 nanometers. In the below curve the tapering can be seen starting.



A sodium vapor lamp, which is used commonly as a street lamp, gives off a red light, as seen in the chart below. (See my article on Lens Cast Correction – January 2020 Silver Spring Camera Club Cable Release for an example of a sodium vapor lit street scene.)



Choosing a filter.



My interest in infrared photography does not lie in making false color images. I like the black and white high contrast effect of the images. So why bother doing infrared photography? It has a different look. If it is plant based and is green, it turns white. Water and a clear blue sky turn black.

I use a 1000 nm filter, XRite 1000 x 2mm (orange line on graph). Comparing the CCD chart against the filter chart, the filter I use does not let in much light until all the channels (red, green, and blue) are contributing more or less equally. Unadjusted images come out of the camera with a light magenta cast, which is easily corrected by a preset white balance. To preset the white balance to get black and white images out of the camera, one needs to shoot out of focus some nice luscious green grass in bright sun to set a manual white balance.

Below is an un-retouched image with dust spots and most likely poor focus on the D.C. side of the Potomac River near the Tidal Basin. The camera white balance has been set to “Preset” so the image does not have a magenta colorcast. The sky is grey because of moisture in the atmosphere.

You can also see a serious vignette. This can be removed with an LCC shot (white plastic, I really like white plastic) in Capture One. If people are interested, I can do a presentation of that too. (See my article on Lens Cast Correction – January 2020 Silver Spring Camera Club Cable Release.)

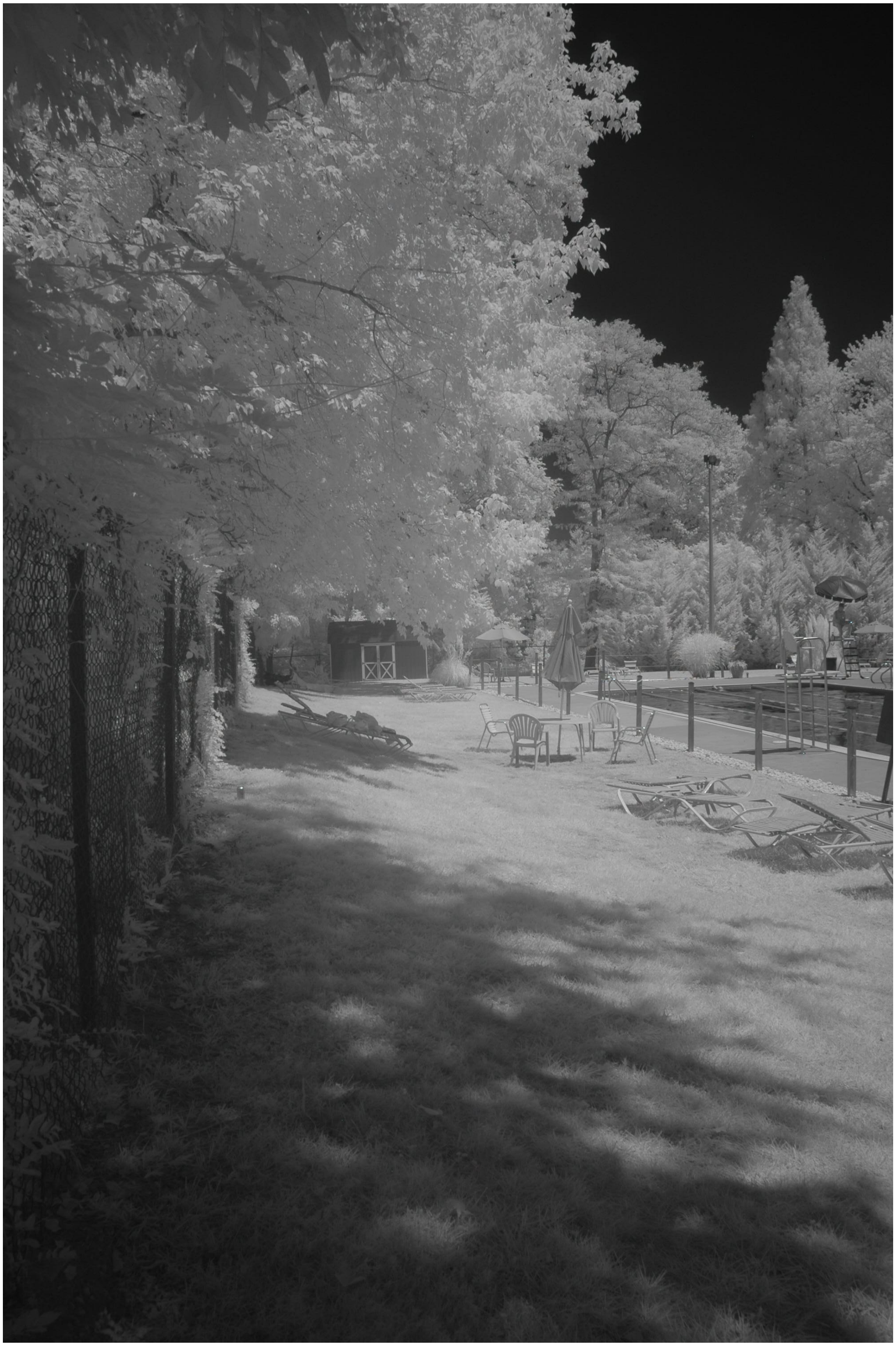
Camera information: Nikon D70
Lens Model: AF-S DX Zoom-Nikkor 18-70mm f/3.5-4.5G IF-ED
Focal Length: 70
FNumber: 11
Exposure Time: 1/3 of a second   Note the rather long shutter time for a brightly sun lit scene.
ISO Speed Ratings: 200

In the above image we can make some observations on how much infrared light is reflected by various materials.

Green plant-based foliage – Extremely high
Rocks, Concrete, and Tree Bark - Sort of Middle
Water and if the sky had been clear with no high clouds of moisture – Extremely low.

We all know that good pool water is more or less clear. The pool water in the below pictures was good. Note how dark the sky is with very little moisture in the air compared to the above picture.

I have had difficulty using the histogram for correct exposure in the infrared spectrum. It lies. Green plant material is usually blown out if trying to do the centered histogram curve.   Therefore, I underexpose probably about a stop or two.



The below image shows the same photo (above) processed using Microsoft word picture settings of +20% brightness and +20% contrast. See how different it looks. This is the desired look I like that infrared photography gives.

When using IR filters, one has to be careful of what one points the camera at, as man made materials can become semi transparent. This includes plastics and clothing made out of, but not limited to, polyester or nylon. Natural materials such as cotton do not become transparent. Below is a picture of a taillight assembly both in color and infrared. Note how the reflector design is much more prominent in the right image. The red lens cap essentially disappears.

Man made materials like nylon and polyester (shown below) have a tendency to turn transparent at longer wavelengths in the near IR spectrum. So, if you are thinking of taking a picture in a crowd of a bunch of people on a bright hot summer day, you might want to think twice. Below is a poor example by a willing model.

In the color, visible light, image at far left, the outline through lumps, show the bra. There is not a change in color.

In the infrared image, near left, the undergarments, both top and bottom, are more visible as they are reflecting infrared light that has already passed through the outer layer and pass through the outer layer again. Note the tag under the neck in the right image. There is no sign of it in the left image. If the outer fabric had a print design on it, the print design would have disappeared.   This is a poor example as I have seen much clearer examples happen unintentionally.   If this had been a front view with no undergarments it could have been very embarrassing to this kind model.

Back in 2006 I took some pictures of the Christmas light display they do at the Mormon Temple. At the time they had already started to transition to LED lights. The color image shows both incandescent and LED lights. The black and white infrared image only shows the incandescent lights. I have tried to line the pictures up vertically. Note what is missing in the bottom picture: on the far left side, the blue and green lights, and on the right side, the most obvious is the Temple itself along with the blue lights. In recent years all the lights used are now LEDs.

Continued on next page.

Another example this time is on a Christmas Eve. Note the LED lights on the top of the porch on the dollhouse in the color picture. The pink picture is the way it comes out of the camera if one forgets to use a manual preset white balance.

Notice in the bottom image how the wrapping paper is missing the decorative print.

Here are the above two images converted to black and white:

Note how the tree in the visible spectrum, top image, is dark. While the tree in the bottom, infrared image, is aglow reflecting the infrared light. Also note how the wrapping paper in the bottom image is missing the decorative pattern.

A couple more pictures this time are at Brookside Gardens. Small pictures are shown first. The same pictures are also shown larger on the following pages. The two pictures on the left were taken with the same camera by changing the filter on the lens and the white balance. The picture on the right is the same as the middle picture but converted to black and white to illustrate the difference between infrared light black and white and visible light black and white. Of course in Photoshop or probably Lightroom, by moving the sliders around for the different colors to change it to black and white, a similar result might be possible.

IR picture after processing

Color after LCC

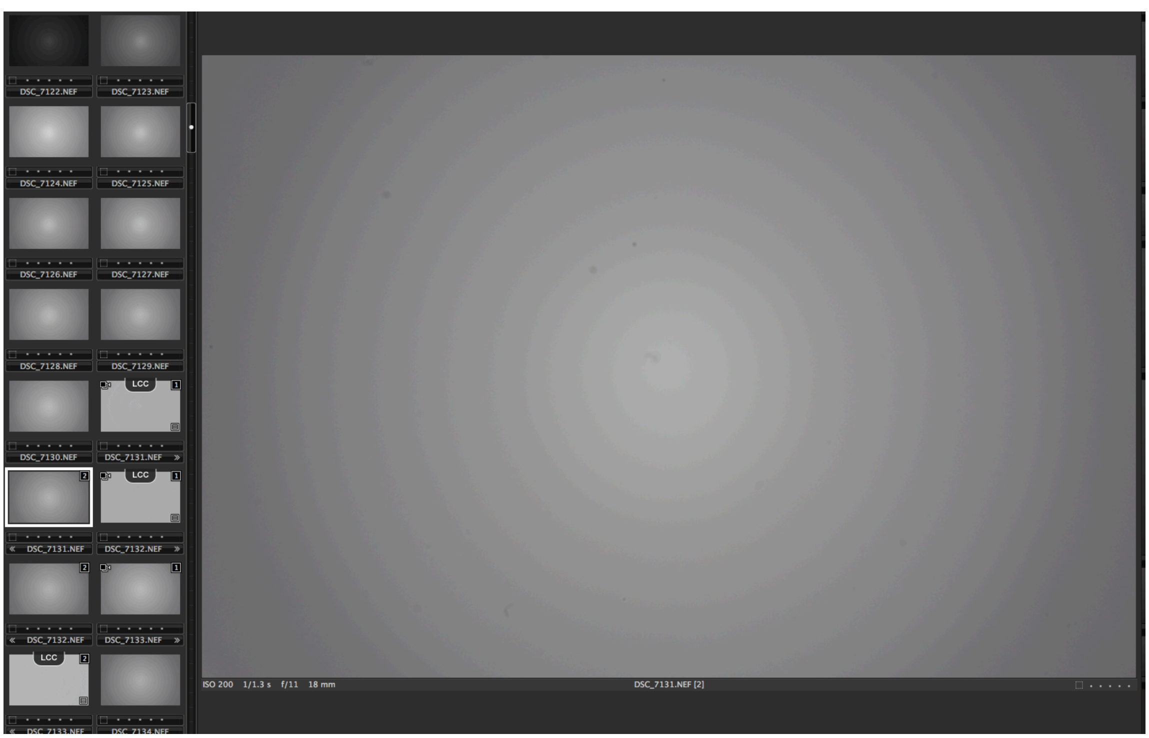
B & W of color picture

IR picture histogram. Note how all the color channels are on top of one another.

Color picture histogram.

One other issue I have come to experience with infrared photography is light fall-off from the center of the lens to the outside corners. This can be corrected with white plastic and an LCC.   (See my article on Lens Cast Correction – January 2020 Silver Spring Camera Club Cable Release.)

My white plastic library shots for LCC's. Note how the center is the brightest spot with the gradual darkening as it gets to the corners.



Here is the image after the LCC has been applied. Note how even the brightness is across the image now. If it were not for the LCC function in Capture One, I would not enjoy taking IR images. I have tried processing images without the LCC and cannot get an image I am happy with because it is the contrast of dark and bright that I like. Without the LCC, the center is blown out and the corners are too dark to have detail.

And the final image after other adjustments.

I suspect they plan to tear down the church I went to as a kid sometime soon. I remember there was a black and white picture of the wooden church that the existing building replaced with a black, cloudless sky. So in keeping with that theme I decided to try some IR pictures before it got torn down.

Picture one is with all filters off the camera so I could compose the image with "Preset" white balance selected for Black and white IR images.

Next was still with no filters but with the white balance set for "Sunlight".

The white balance set to “Sunlight” with the 1000nm infrared filter. Note magenta cast.

And the last picture with the white balance set to “Preset” with just the 1000nm infrared filter. (1/3 second at f/13.)

The above four pictures are as they came out of the camera. In the pictures with the IR filter the center brightness can be spotted.

Car windows have a greenish blue tint to block the infrared heat from the sun. A quick snap shot out the car window. (This was hand held at a half second, f20. There maybe some camera shake. The purpose is to show how much infrared light the tinted glass window of a car blocks.)

So if you want to jump into the world of near, near infrared photography (700+nm and less than 750nm) with filters please give Dan a call. See first page of document for phone number and website. (Disclaimer: I bought his filters 15 or so years ago. I have been happy with what I bought. I have not used infrared filters by other manufacturers so I have no reference to who might be better.)

Or if you are going after the longer wavelengths in the near infrared spectrum, 800nm (no visible light whatsoever) and above, I suggest going with a modified camera. The reason for a modified camera is that if only the sensor has the IR filter on it, the camera can still autofocus, and you can see through the lens to compose the image without taking a filter off and then putting it back on.   Also note, a tripod is almost an absolute must do to the long exposures.

Some suggestions for infrared camera sources:

Dan at MaxMax.com for filters and cameras
KEH to buy second hand camera that has already been modified
Life Pixels to have your existing camera modified (if still in business)
Search the Internet

If you have any questions about this article or the LCC article please see me during a meeting. If a demonstration is desired, that can be arranged.

Ken