What color is the night sky?

BY JOSEPH A. SHAW

When asked the color of the night sky, it is tempting to say, "black, of course!" However, that is not really correct. It looks black to us because there is not enough light to stimulate the color-sensitive cones in our eyes, even though there is light in the nighttime sky, and it has color. Away from city lights or other interfering light sources, the night sky, illuminated by moonlight is blue, similar to the sunlit daytime sky.

In the daytime, the sky away from the sun appears blue, as long as there isn't excessive haze. Sunlight contains a large range of wavelengths, λ, including the small spectral region that our eyes respond to (the "visible" range, from about λ=425 nm to λ=700 nm). Because nearly equal portions of all visible colors exist in sunlight, it is almost white. When the white sunlight is scattered by air molecules in the earth's atmosphere, about 8 times more blue light than red light is scattered. The stronger scattering for blue light occurs because the amount of light scattered at each wavelength is proportional to $1/\lambda^4$. This scattering by particles that are very small relative to the wavelength of light, is called Rayleigh scattering after Lord Rayleigh, who published the theory explaining the blue sky in 1871.

How about at night? When the sun goes down, where does the blue go? The answer seems obvious- when the sun goes down, there is no more sunlight, so the sky is black. But if the moon comes up as the sun goes down, what then? Moonlight is simply reflected sunlight, which is still scattered by air molecules in the Rayleigh fashion that gives rise to a blue sky. Therefore, with a full moon out, the night sky is blue. We cannot see the blue because moonlight, which is about 10 million times weaker than sunlight, is not bright enough to stimulate our color vision.

Reading about the blue night sky in one of my favorite books, *Rainbows, Halos, and Glories,* by Robert Greenler, gave me the idea of letting my fourth-grade son photograph the effect as a science fair project. The poster that he made several months later excited me enough that, since then, I have spent many nights taking photographs of the night sky. An example is shown in Figure 1, in which the sky appears blue, similar to the daytime sky. The star streaks are the best evidence that this picture is indeed taken at night. This picture was taken in the foothills west of Boulder, Colorado, near midnight on July 1, 1996, with a full moon to the left and well out of the picture. I used a Nikon EL-2 camera with a 28-mm lens to expose ISO-100 Kodak Ektachrome film at f/3.5 for 13 minutes. Photographs of a moonless sky with the same exposure show the familiar star streaks in a black sky.

Taking pictures like this requires a camera that can be operated on manual exposure in bulb mode, and a solid tripod. I use a shutter release cable to lock my shutter open for the desired time period, but some newer cameras can be programmed for a long time exposure (keep in mind that those newer cameras become inoperable if the battery gets cold). Once you gather your equipment and film, choose a location away from city lights. I have taken similar photographs from my backyard, late at night when all the neighbors had their lights off, but the sky color was not as rich as I obtained away from town (photographing the blue sky at night from inside larger cities may be impossible). My best success has been in mountain settings with my camera pointed away from distant cities. Including mountains, trees, or other objects of recognizable color in part of the picture helps you monitor how well the film maintains its color balance during the long exposures. Filters may be used for color correction if you want to get serious about it.

Pointing the camera near Polaris, the North Star, results in star streaks that are more obviously circular than those obtained with the camera pointed far away from Polaris. Varying the exposure time in steps from a typical daytime setting of 1/1000 second to the night setting of several minutes or longer results in a sequence of photographs that show the sky gradually lightening from black to daytime-like blue.

Though no special film is required, it is interesting to use films of different speeds. Table 1 outlines

Figure 1. The blue sky at night, caused by Rayleigh scattering of moonlight. (ISO 100, f/3.5. 13 min.)

some of my better experiences with different films, always shooting within two days of a full moon. ISO-1600 Professional Ektachrome slide film gives nice blue saturation, but the fast exposure times result in short star streaks, making the overall effect perhaps less impressive. ISO-100 or 200 films allow exposure times on the order of 10 minutes, producing a nice blue sky with long star streaks. It is especially fun to identify streaked constellations in a daytime-like blue sky background. Most importantly, be sure to have plenty of time, and enjoy the night sky. I invite correspondence via e-mail at jshaw@etl.noaa.gov to share your experiences if you join the ranks of night-sky photographers.

Film Type	Speed (ISO)	Exposure	Comments
Kodak Ektachrome™	100	~ 10-15 min @ f/3.5	Good, with long star streaks.
Kodak Ektachrome™	100	~ 15-25 min @ f/5.6	Also very nice results.
Kodak Ektachrome™	200	~ 5-10 min @ f/3.5	Fast enough to experiment with out staying up all night.
Kodak Ektachrome™	1600	~ 1 min @ f/2	Stars appear as points; good color saturation.
Kodak Gold™ (prints)	200	~ 5-8 min @ f/2	Inexpensive film; works great.

Table 1. Some successful combinations of film speeds and exposures for taking photographs at night, of the blue sky under a full moon.

References

1. R. Greenler, Rainbows, *Halos, and Glories* (Cambridge Univ. Press, Cambridge, U.K., 1980).

Joseph A. Shaw is electronics/optical engineer at NOAA Environmental Technology Laboratory, Boulder, Colorado.

In 2001 the author moved to Montana State University - Bozeman, where his new email address is jshaw@ece.montana.edu.