

Re: The physics behind depth-of-field...?

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BD wrote:

Hey, all.

I'm an amateur photographer, and I understand a little about the behavior of light - but I'd like to understand it on a bit of a more fundamental level.

For example: I know that in photography, if your aperture is small, your depth of field is greater - that is, objects are in focus even if they are not exactly at your focal range.

I also know that the width of the aperture has an inverse effect on the size of the depth of field: large aperture = thin depth of field.

My question is, why?

What is it about varying size apertures that affects light's focal range in this fashion?

Good question. First off, it's important to realize that "the aperture" is not just any hole located anywhere in the optical train; it has a specific location with respect to other important planes in the optical system- the entrance and exit pupils, and the image plane. There is a definite relationship between the optical field on the aperture plane and the optical field on the image plane- they are Fourier transforms of each other. Furthermore, the aperture plane, entrance pupil, and exit pupil are all conjugate planes- linear maps, or 'images' of each other. To be a little more specific, a plane wave incident on the entrance pupil will be a plane wave at the aperture plane and exit pupil, and be an Airy disk at the image plane (for circular apertures). The size of the Airy disk is

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inversely related to the size of the aperture hole, and the 'depth' of the Airy disk (sometimes I call it an Airy football) is also inversely related to the size of the aperture hole because the planes are Fourier transform pairs of each other.

So a better way to phrase your question is "Why are the aperture and image planes Fourier transform pairs?". The main reason is that lens surfaces are (almost always) spherical caps. So the light field takes on a spatially-dependent phase term that matches up exactly with the free propagation of spherical waves. When you write down the expression for the propagation of a spherical wave through a spherical interface, what you get looks exactly like a Fourier transform expression. Detailed derivations are all over the place, but the standard one is covered in Goodman's "Introduction to Fourier Optics". Chapter 4, I believe.

I believe that the principle involved is similar to that which tells us that a solar eclipse can be viewed on a piece of paper behind a piece of foil with a tiny hole in it - but not a large hole.

Can someone reference an article that addresses this topic?

Thanks!!

BD

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