The Phenonenon of Eclipsed Bokeh

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ABSTRACT

Out-of-focus points of light, when obscured by out-of-focus occluders, become "eclipsed" by a sharply-focused traveling occlusion edge which can move at a speed different from that of the occluder, and even in the opposite direction. The phenomenon can produce interesting visual effects in photos and motion pictures.

CCS CONCEPTS

• **Computing methodologies → Image and video acquisition**; **Computational photography**.

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1 INTRODUCTION

"Bokeh" refers to the visual quality of the out-of-focus regions produced by a particular camera lens. The term, meaning "blur" in Japanese, shot into popularity in professional photography in the late 1990's and has more recently entered into popular use through smartphone camera features which try to simulate the effect of bokeh seen in larger cameras.

Bokeh is, to first order, the circle of confusion formed when a point of light in the scene is at a depth which focuses either in front of or behind the image plane. In real lenses, the bokeh is not a perfectly circular disc or even in intensity. It is shaped by the blades of the iris, often brighter around the edges, occasionally blemished by optical imperfections, and can change shape depending on where it lies in the frame due to occlusions within the lens.

2 ECLIPSED BOKEH

The shape of the bokeh can also be *eclipsed* by the presence of an occluder in the scene between the point of light and the camera lens. The effect is most easily seen in motion picture cinematography, when a foreground object moves in front of an out-of-focus point of light. Notably, the edge of the eclipsed bokeh appears sharp regardless of whether the occluder happens to be in focus. And more notably, the speed of the eclipse traveling over the bokeh can be either faster or slower than that of the occluder, or can even travel in the opposite direction. The result is a noticeable and unexpected pattern of visual motion independent of the motion and sharpness of the foreground and background elements. In this poster, we enumerate the optical arrangements in which each of these conditions may appear.

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2.1 (A) Focal plane in front of light, occluder behind focal plane

With the lens focused in front of the light source, rays from the light converge in front of the image plane and subsequently diverge into a circle of confusion on the image plane. As an occluder coming from above begins blocking rays which hit the lens, the bokeh of the light becomes eclipsed toward the bottom of the image sensor, which is at the top of the displayed image. The occluder is also out of focus, though less so, and the eclipse begins just as the bokeh of the occluder fully covers the bokeh of the light as in Fig. 1(A). Since the center of the occluder's bokeh is already inside the bokeh of the light, the apparent speed of the eclipse is faster than the motion of the occluder, and they go in the same direction.

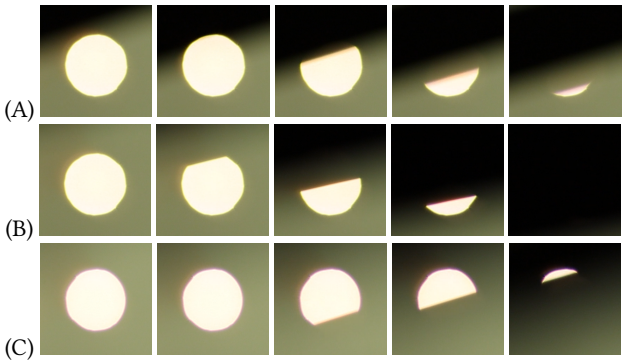

Figure 1: An occluder moves top-to-bottom in front of an out-of-focus light as in cases (A), (B), and (C).

2.2 (B) Focal plane in front of light, occluder in front of focal plane

If the occluder is moved in front of the focal plane, then its rays will converge behind the image plane, as illustrated in Fig. 2. As the occluder comes from above, it begins to eclipse rays from the light which hit the lens as soon as the occluder's bokeh touches the outside of the light's bokeh as in 1(B). This begins at the top of the bokeh, so the occluder and the eclipse still travel in the same direction. The light's bokeh is fully eclipsed when the bokeh of the occluder completely passes the light's bokeh. As a result, occluder appears to move faster than the line of the eclipse.

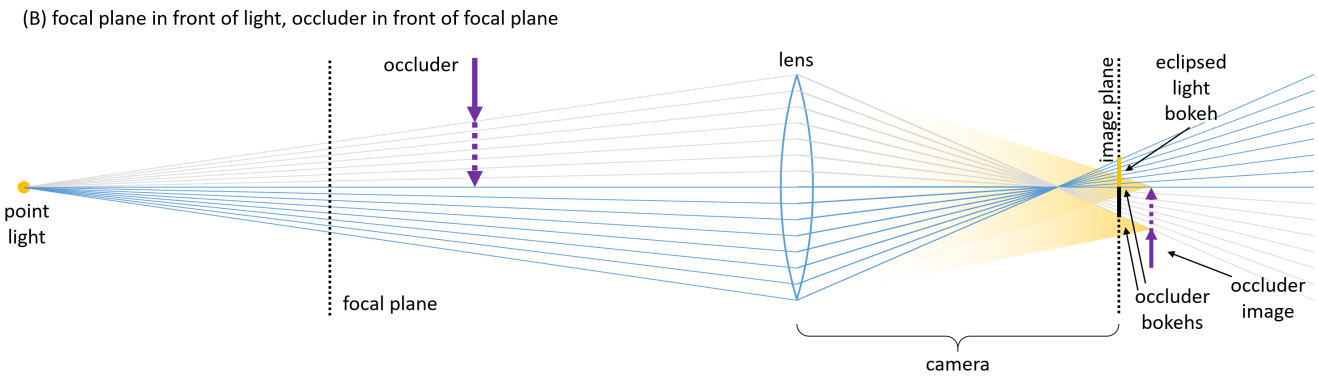

Figure 2: Optical diagram for case (B) of eclipsed bokeh. Cases (A) and (C) are illustrated in the supplemental material.

Figure 3: The foreground actor creates several examples of Case (B) eclipsed bokeh from background point lights.

Figure 4: A hand eclipses the bokeh of background foliage, causing it to appear sharper and distorted near the fingers.

2.3 (C) Focal plane behind light

If the lens is focused further than the light's distance, such as all the way to infinity, the rays from the point light converge behind the image plane. An occluder in front of the light will focus even further behind the image plane. As seen in 1(C), as the downward-moving occluder begins to block rays from the light from hitting the lens, it eclipses the bokeh of the light starting with the *bottom* of the displayed image. Thus, the bokeh of the light becomes eclipsed, counter-intuitively, from the opposite direction of the motion of the occluder. The bokeh of the occluder envelops the entirety of the bokeh of the light during the eclipse. The speed of the eclipse compared to the speed of the out-of-focus occluder on the image plane will be the same if the occluder has twice the bokeh size of the occluder, which occurs when the occluder focuses at double the distance behind the image plane as the light.

3 DISCUSSION

The accompanying video shows each of these cases for a set of out-of-focus incandescent holiday lights as an occluding wand is waved over them.

The interesting effects of eclipsed bokehs can be noticed in a variety of naturally occurring scenes, often in over-the-shoulder shots with a shallow depth of field as in Fig. 3.

The camera is focused on the actor on the left, so that the closer out-of-focus foreground actor on the right eclipses the bokehs of several background point lights according to Case (B). Since in this case the eclipse begins as soon as the foreground actor's blur touches the light's bokeh, a dark area appears between the light bokehs and the actor when the overlap is small. And since a light's bokeh is not fully eclipsed until the actor's bokeh moves past it, two nearly-eclipsed bokehs appear to shine through the foreground actor's cheek.

In Fig. 4, an out-of-focus hand eclipses the bokeh of out-of-focus foliage seen through a window. Around the fingers, the blurry regions of the background come into sharper focus in the direction perpendicular to the outline of the hand. In motion (see video) the moving hand appears to distort the background, giving the areas around the fingers a motion which is different than the motion of the fingers themselves.

The effect of eclipsed bokeh is interesting and noticeable, and could become more commonly and effectively used in artistic photography and cinematography once there is greater awareness of the effect.