Whether Insects See Anomalous Images Located Near a Lens or Not? Verification of Lens Equations for Anomalous Images and Application of the Simple Eye of an Insect

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The major result from recent studies is that there are two additional small images formed at the front and the back side of a convex lens, which were termed “secondary real images”. Secondary real images are formed by internal reflections of rays within a lens that are not parallel to the optical axis. Equations to calculate the location of secondary real images of convex lens were successfully derived using a matrix approximation method. However, it was not investigated where secondary real images appear for a plane-convex lens. We are interested in such secondary real images in the microscopic world, so we examined a simple eye for an insect. Through our studies, we obtained four results: (1) equation to determine the location of secondary real images for a plane-convex lens, (2) equation to determine the location of secondary real images for a convex lens whose sides have a different radius of curvature, (3) a new definition of the “secondary focal point” corresponding to secondary real images, and (4) determination of location of secondary real images in a simple eye. To obtain (1) and (2), we derived equations for secondary real images using a thick-convex lens model and verified its accuracy by constructing a new matrix calculation. Also, we defined the position of the secondary focal point by substituting infinity for the distance between the lens and the light source into the equation we derived. From (4), it was found that the lens of a simple eye has a spherical surface but that each side of the lens has a different radius of curvature, which leads to the discovery that the distance between secondary real images and the retina is closer than that between real images and the retina. Therefore, it is implied that insects see through secondary real images.

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