Anti-mirror optical illusion could increase LED luminosity and laser power

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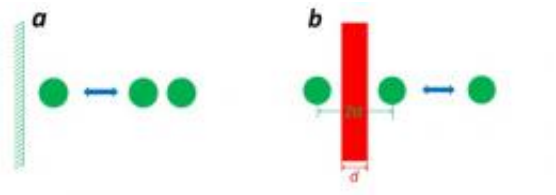

(a) In the mirror effect, an object placed in front of a mirror is equivalent to two identical objects. (b) In the anti-mirror effect, two identical perfect electrical conductors (PECs) on both sides of a perfect lens are equivalent to one object. Image credit: Yadong Xu, et al.

(PhysOrg.com) -- By making multiple objects appear to look like only one using a "perfect lens," scientists have demonstrated a new optical illusion that could have practical applications in lighting systems. Normally, a mirror makes one object appear to look like two objects (the original object and its reflection). Since the new set-up does the opposite, the scientists have called the concept the "anti-mirror effect."

Huanyang Chen, a researcher in metamaterials and transformation optics from Soochow University in Jiangsu, China, and his colleagues have discovered and modeled the anti-mirror effect. The ability to make multiple objects look like one using “overlapped illusion optics” has not been found in nature before now.

To demonstrate the basic idea, the researchers explained that two identical cylindrical perfect electric conductors (PECs) are placed on opposite sides of a perfect lens made of a negative refractive index material. When viewed from the far field (beyond a certain distance) on either side of the lens, the two PECs look like one. Further, when the scientists replaced one of the circular PECs with an illusion device with an elliptic cylindrical PEC, both PECs look like only one circular cylindrical PEC.

Further elaborating on this effect, the researchers showed that illusion devices with elliptic cylindrical PECs can be used in place of both real cylindrical PECs. Once again, the two illusion devices look like one PEC. As the scientists explained, this effect occurs because the two illusion devices are close enough together so that their virtual illusion spaces overlap. Inside this shared region, both illusion devices form a single PEC image.

“The two PECs on both sides of the perfect lens follow the image-forming principle so that each of them is overlapped with the virtual image of another,” Chen explained to *PhysOrg.com*. “The anti-mirror effect stems from the evanescent wave amplification of the perfect lens.”

The anti-mirror effect could have applications in both solid-state lighting, such as LEDs, and in coherent light sources, such as lasers. Currently, one of the biggest challenges in LED development is achieving a high enough luminosity for general lighting purposes. One method of increasing LED illuminance is to package many LEDs inside a single bulb; however, the problem is that the lamp's spatial illumination is not uniform. Using the new overlapped illusion optics, the researchers show that the images from multiple LEDs in different places can be overlapped to make the bulb look like a single-LED source with high, uniform illumination.

The proposed overlapped illusion optics method could also increase the power and preserve the spatial uniformity of lasers. Usually, spatial uniformity degrades when two coherent sources are aligned due to interference. Using the same configuration as the LEDs, multiple coherent sources can be operated at the same frequency and phase to double the light amplitude and quadruple the total power of the coherent system. These improvements cannot be achieved using traditional beam-combining techniques.

“Our current work is just a conceptual model,” Chen said. “We have recently realized the first illusion optical device – an “invisible gateway” – by using a transmission-line medium.” See arxiv.org/abs/1005.3425 .

More information: Yadong Xu, et al. “Anti-mirror effect: A perfect lens brings a brighter future.” arXiv:1011.0542v1 [physics.optics] arxiv.org/abs/1011.0542