Scientists find a way to extract color from black

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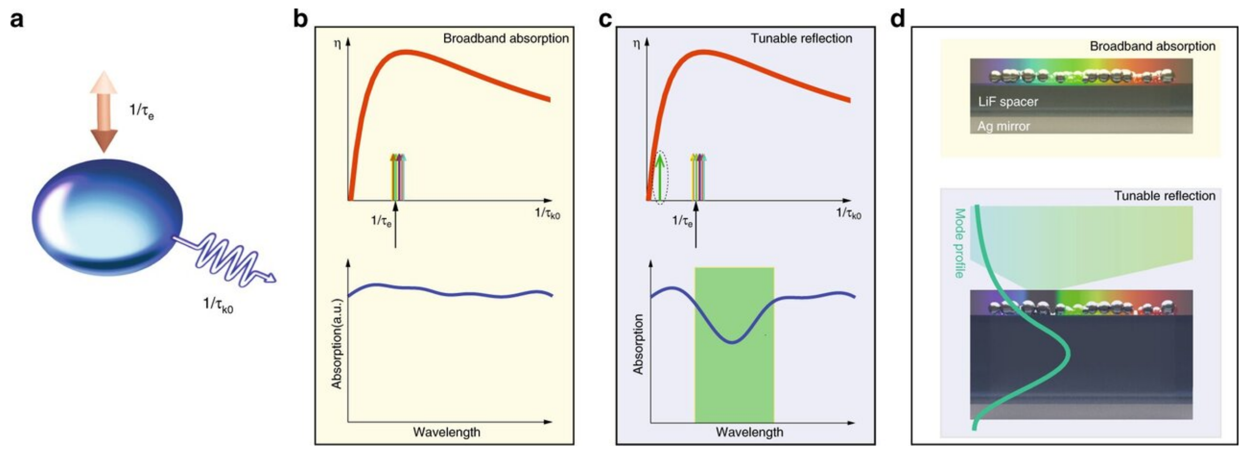

A disordered system with transition from broadband absorption to band-limited reflection/transmission based on coupled mode theory. Credit: *Nature Communications* (2020). DOI: 10.1038/s41467-020-15349-y

Scientists have developed a way of extracting a richer palette of colours from the available spectrum by harnessing disordered patterns inspired by nature that would typically be seen as black.

Colours that we see in nature often come from nanoscale patterns that reflect light back in particular ways. A butterfly's wing, for example, might appear blue because tiny grooves in the surface of the wing cause only blue light to be reflected.

When surfaces appear black or white, however, it's often because the nanoscale structures are completely disordered, causing all the light to be either absorbed or reflected.

A team of researchers led by the University of Birmingham has now found a way to control the way light passes through these disordered surfaces to produce vivid colours.

The team, which includes colleagues in Ludwig Maximilian University of Munich, Germany, and Nanjing University in China, has compared the method to techniques that artists have exploited for centuries. Among the most famous examples of this is the fourth-century Roman Lycurgus cup, made from glass that appears green when light shines on it from the front, but red when light shines through it from behind.

In a modern advance, the research team demonstrated a way of finely controlling this effect to produce extraordinarily precise colour reproduction.

The different colours in the image are represented in different thicknesses of a transparent material—such as glass—on a lithographic plate. On top of this, the researchers deposited the disordered layer—in this case made of random clusters of gold nanoparticles. Finally, beneath this layer, the team placed a mirrored to form a transparent cavity. The cavity is able to trap particles of light, or photons, inside. The photons behave like waves inside the cavity, resonating at different frequencies beneath the lithographic surface and releasing different colours according to the length of each wave.

By using this technique, the team was able to reproduce a Chinese water colour painting with exquisite colour accuracy.

Lead researcher, Professor Shuang Zhang, explains: "The different ways in which nature can produce colour are really fascinating. If we can harness them effectively, we can open up a treasure trove of richer, more vivid colours than we have yet seen."

Co-author Dr. Changxu Liu adds: "In physics, we're used to thinking that randomness in nanofabrication is bad, but here we show that randomness can lead to be superior to an ordered structure in some specific applications. Also, the light intensity within the random structures that we produced is really strong—we can use that in other areas of physics such as new kinds of sensing technologies."

More information: Peng Mao et al, Manipulating disordered plasmonic systems by external cavity with transition from broadband absorption to reconfigurable reflection, *Nature Communications* (2020). DOI: 10.1038/s41467-020-15349-y

Provided by University of Birmingham