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# Liquid crystals enable tunability to bound states in the continuum

## ICFO researchers have demonstrated a way to tune the properties of anisotropy-induced bound-states in the continuum -states that can hold light inside a structure instead of letting it just escape- using liquid crystals.

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When light is inside a structure, it travels off into open space through a radiative process. This range of outgoing light is continuous, meaning it includes all frequencies within it. All frequencies, but the ones corresponding to the so-called **bound states in the continuum (BICs)**. BICs are the exceptions that prove the rule. At these specific frequencies, the structure surprisingly does not leak energy by radiation; instead, it keeps the light trapped inside it. This makes BICs potentially interesting for settings where extremely narrow bandwidths as well as efficient energy storage and transmission capabilities are needed, such as certain types of sensors, laser cavities, and filters.

BICs typically exist at a specific frequency and when light propagates in a particular direction, with both aspects being determined by the material's refractive index and geometry. These structural features become fixed during the fabrication process, and so do BICs. If BICs are fixed, it gets hard to adapt to different operational conditions or to correct errors occurring during fabrication, which might lead to an undesired frequency and direction.

ICFO researchers, **Dr. Marlin Baral**, **Dr. Samyobrata Mukherjee**, **Pilar Pujol-Closa**, **ICFO and UPC Prof. Lluis Torner**, and **Dr. David Artigas**, have explored a new platform that allows for more dynamic control over these states. In a recent publication in Optica, they reported, for the first time, the observation of a particular type of BIC (anisotropy-induced interference BIC), whose existence was elucidated eight years ago by themselves. Moreover, through a specific set-up based on specially designed waveguides and a liquid crystal core, the team managed to change at will the frequency of the detected BICs.

? To achieve this, the team used liquid crystals - matter that can flow like a liquid but also ha
e some molecular order, similar to a crystal. The researchers took advantage of the fact th
t the crystal's optical properties can change in response to external stimuli. They th
n demonstrated that, depending on these properties, the frequency of the BIC also change
. Specifically, they applied a voltage to reorient the liquid crystal molecules. This realignme

t modified the conditions under which light propagates without altering the geometry or t e material media at all. This way, the team was able to select one BIC or another after t e fabrication process, effectively choosing which frequency was captured within the structur . The successful results did not come out of the blue, though. ï¿½We already had the ide in mind since the publication of the theoretical article, back in 2017,ï¿½ shares Dr. David Ar igas, senior author of the paper. ï¿½We started working on it that same year, and more int nsively in the last three years, when Marlin brought her experience in liquid crystals to the g oup.ï¿½ He admits that the process was no easy feat. They had to face new challenges very day, from the fabrication of samples to the interpretation of the results, which, as Davi recalls, did not initially fit with the theory. ï¿½It has been a long-distance race, a whole arathon,
¿½ he adds. In the end, the concerted efforts paid off, and the team achieved the long-st nding goal of dynamically modifying the frequency of anisotropy-induced BICs. ICFO resea chers are now seeking ways to extend and further develop the proposed method; for instan e, to include control over the direction of light propagation, something they have alread demonstrated

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Waveguide used in the study. Credit: ICFO.