Perovskite semiconductors seeing right through next generation X-ray detectors

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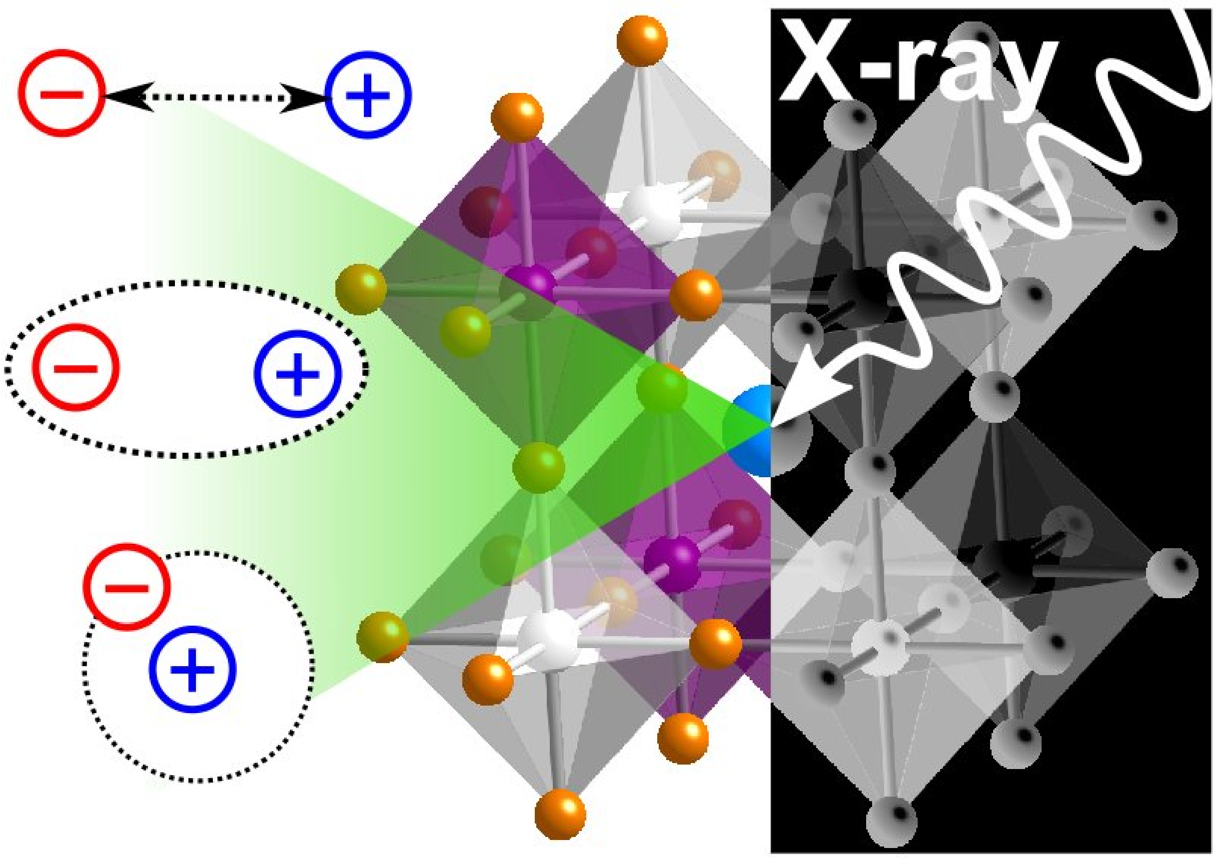

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From observing celestial objects to medical imaging, the sensitive detection of X-rays plays a central role in countless applications. However, the methods used to detect them have undergone an interesting evolution of their own.

X-ray detector designs vary in shape, function and ultimately performance. For example, indirect scintillators detect X-rays by converting the high energy of X-ray photons into light which is visible to the naked eye. This down-shifting makes it possible to use well-established optical detectors to generate a detectable electronic signal. Besides the need for large, complicated multi-component devices, such designs inherent significant limitations when applied for imaging. Direct conversion semiconductor detectors directly absorb and convert X-ray photons into electrical charge, which can then be collected to generate a digital signal. Direct conversion configurations are not only much simpler, but also allow for the imaging smaller details.

KU Leuven researchers from the Roeffaers Lab and the Hofkens Group have now put forward a very promising direct X-ray detector design, based on a rapidly emerging halide perovskite semiconductor, with chemical formula $Cs_2AgBiBr_6$. Perovskite is the general name for a particular type of periodic crystal structure, which, when composed of heavy elements like silver (Ag) and bismuth (Bi), are ideal for direct X-ray conversion because of their ability to combine both heavy atomic nuclei – for efficient X-ray absorption – with their excellent charge formation and transport properties.

The researchers singled out the all-inorganic double metal halide perovskite $Cs_2AgBiBr_6$ as one of the strongest candidates because of its high X-ray sensitivity and excellent structural stability. By optimising the materials and lowering the operating temperature, they were even able to improve the X-ray sensitivity of the device tenfold, ultimately peaking near 500 times more sensitive than commercial direct conversion X-ray detectors on the market – commonly based on pure selenium (Se).

Importantly, the researchers studied their simple single crystal $Cs_2AgBiBr_6$ detector at both room and low temperatures to track physical features that are beneficial for the efficient conversion of X-rays into a collectible signal. This is an extremely novel approach, and one that offers a generic method for screening other potentially good X-ray detecting mediums. Using this method, the researchers developed an extensive photo-physical model to account for the large jump in X-ray sensitivity when operating at reduced temperatures.

This research is a big step forward in the development of new, cheap and easy to make, and highly sensitive X-ray detectors based on perovskite semiconductors. The breadth of possible applications is vast, stretching from more refined fundamental research, all the way to improved medical diagnostics.

The researchers recently published their discovery in the high-impact material science journal *Advanced Materials*.

More information: Sergii Yakunin et al. Detection of X-ray photons by solution-processed lead halide perovskites, *Nature Photonics* (2015). DOI: 10.1038/NPHOTON.2015.82

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Julian A. Steele et al. Photophysical Pathways in Highly Sensitive Cs2 AgBiBr6 Double-Perovskite Single-Crystal X-Ray Detectors, *Advanced Materials* (2018). DOI: 10.1002/adma.201804450

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