Researchers Enable Thinnest Quantum Light Source by New 2D Layered Materials

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Recent advances in spontaneous parametric down-conversion (SPDC)-based quantum light sources based on two-dimensional layered materials have been made by a team led by Prof. REN Xifeng from the University of Science and Technology of China (USTC) of the Chinese Academy of Sciences, collaborating with Prof. QIU Chengwei and Dr. GUO Qiangbing from the National University of Singapore (NUS). The study was published in Nature.

Miniaturization and integration are strategies broadly employed in optical quantum systems to enhance their scalability and stability, thus providing a path to scalable and practical solutions for optical quantum computing and quantum communications.

In this study, researchers reported a van der Waals crystal ($NbOCl_2$) featuring monolayer-like excitonic behavior in bulk form, indicating a verified weak interlayer electronic coupling. Theoretical calculations implied that such weak interlayer coupling derived from the strong ionic Nb-Cl bond in the crystal.

Second-harmonic generation (SHG) is the lowest-order nonlinear optical process where the second order nonlinear optical susceptibility is responsible for the generation of light at second-harmonic frequency. Despite having a high second-order nonlinear susceptibility, conventional 2D materials (e.g., WS_2) show a decreasing SHG response as the layer number increases, while the scalable SHG intensity in $NbOCl_2$ is up to three orders of magnitude higher than that in monolayer WS_2.

Notably, this newly-reported crystal flake is as thin as 46nm. The strong second-order nonlinearity of crystal $NbOCl_2$ enables a SPDC process, a second-order nonlinear process in which a photon from a strong pump laser is converted to a photon pair, which means a detection of one photon of the pair heralds the presence of the other.

The discovery makes crystal NbOCl2 both the thinnest, and the first two-dimensional SPDC source ever reported.

The findings of this study not only provide an integrable quantum light source for optical quantum information technology, but also open a new direction in the study of optical nonlinearity in two-dimensional materials.

Read the original article on Chinese Academy of Sciences (CAS).