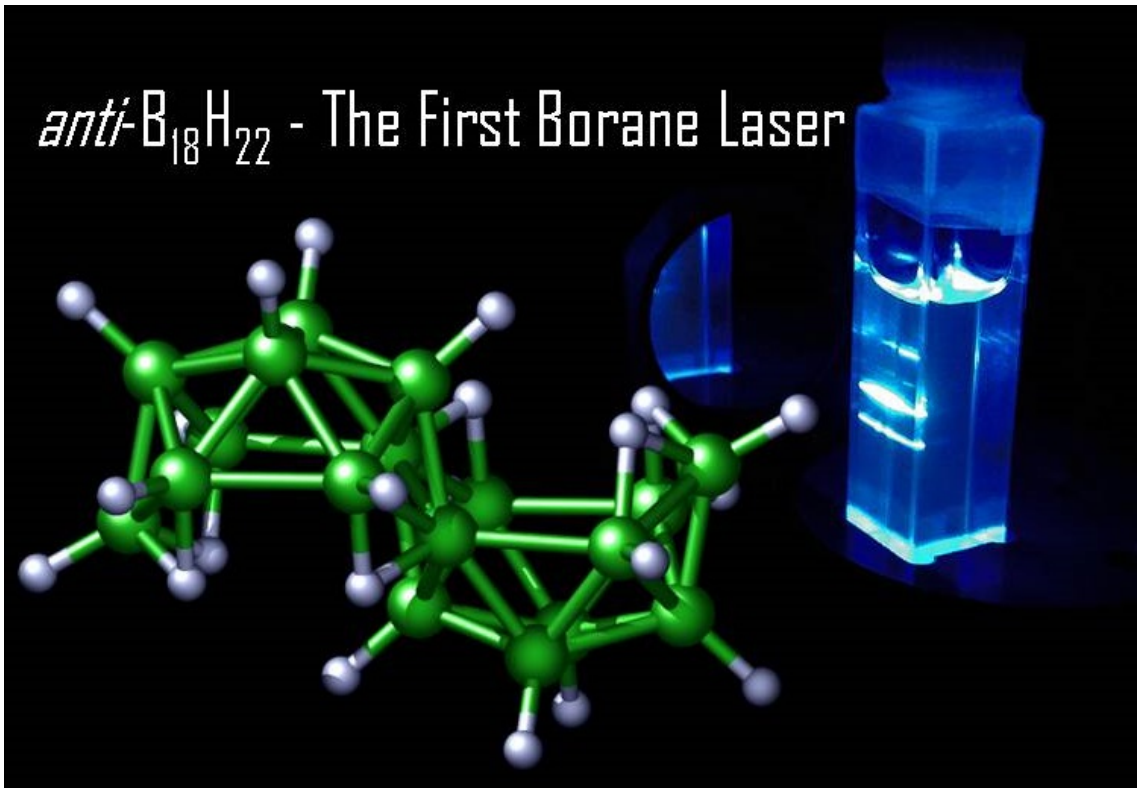
Breakthrough in laser technologies

The first borane laser in the world has been developed by the Institute of Inorganic Chemistry of the CAS

Scientists from the Institute of Inorganic Chemistry of the CAS under the guidance of Dr. Michael G. S. Londesborough in cooperation with colleagues from the Spanish National Research Council have developed a new type of laser on a purely inorganic basis. A compound of boron and hydrogen from a solution emits a blue light and can become the basis of new modern lasers, which would be more ecologically friendly and more economical. The scientists used a borane for the first time in history to acquire laser light. The research results were published in the prestigious journal Nature Communications.



A picture of the laser solution and a virtual depiction of anti-$B_{18}H_{22}$ (Image: ÚACH and CSIC)

The scientific team under the guidance of Dr. Michael G. S. Londesborough from the Institute of Inorganic Chemistry of the Czech Academy of Sciences and Dr. Luis Cerdán from the Spanish National Research Council (CSIC) have discovered a new type of laser based on purely inorganic material (i.e., entirely without carbon atoms) – a compound of boron and hydrogen – , which emits from the solution a blue laser light. This work, published in the journal *Nature Communications*, shows how this new material emits blue light that is characterised by high efficiency and resistance to degradation and the spectrum of which is useable among other in spectroscopy and in the treatment of materials.

The first laser was developed in 1960. Today, 55 years later, we are still looking for new materials, which emit efficient, controllable and stable blue laser light, which would also be a low coast and simple method of production and treatment. "Currently, there *are many commercial materials that come close to these requirements, but they have certain practical disadvantages. In our study, we present a solution that had the potential to overcome these disadvantages*," explains Inmaculada García-Moren, a research employee from the Institute of Physical Chemistry "Rocasolano", CSIC.

New application of a known compound

Although it is not an entirely new material, hydrides of boron, i.e., boranes, were used to acquire laser light for the first time in history. Specifically, the researchers focused on solutions of anti- $B_{18}H_{22}$. "*Boranes have three-dimensional cage-like molecular architecture with highly delocalized electron structures*," states Dr. Michael Londesborough, a specialist on boranes from the Institute of Inorganic Chemistry. "*The structure of anti- $B_{18}H_{22}$ is reminiscent of a split football, where the two halves are joined by molecular orbitals*." Of all the known laser materials, i.e. organic dyes, quantum dots, halide perovskites, boranes in terms of structure and properties are most similar to organic dyes that emit laser light in an efficient and controllable manner (high energy with adjustable colour), however, they are quite susceptible to degradation, which requires frequent replacement of the laser medium.

The new borane laser material exhibits significantly greater resistance to degradation as compared with many modern commercially available blue dye lasers. This high resistance to degradation reduces the frequency of the change of the liquid medium, which in turn leads to lower costs, operational risks and environmental impacts due to the handling of solvents, which are often toxic and flammable.

"*Currently, our science team is working on the synthesis of new boranes, which emit light at other wavelengths (colours),*" adds Dr. Michael Londesborough. This would open the door to other possible applications, for example in dermatology (removal of tattoos, scars and acne, treatment of vascular injury, etc.). Moreover, the excellent solubility of *anti*-$B_{18}H_{22}$ in organic environments allows the incorporation of the material into polystyrene polymer matrices, without the loss of their fluorescence properties. The resulting polymer nanocomposite materials based anti-B18H22 exhibit interesting optic properties and have a potential for use as coherent light sources in optoelectronics, spectroscopy, in detection devices and as chromophores in luminescent solar concentrators.

"*We still have a lot of work to do before these compounds are commercially available, but the scientific importance of this discovery represents a major milestone in the development of lasers, since the revelation of the new laser materials does not happen often*," concludes Dr. Luis Cerdán, research employee from the Institute of Physical Chemistry "Rocasolano", CSIC. Dr. Michael Londesborough from the Institute of Inorganic Chemistry adds: "*We are really excited by this discovery. Boranes with the unique molecular structures and high photostability are a new and earlier unutilised source for laser technologies*."

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Luis Cerdán, Jakub Braborec, Inmaculada García-Moreno, Angel Costela, and Michael G. S. Londesborough. **A borane laser**. *Nature Communications*. DOI: 10.1038/ncomms6958