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Multigap superconductivity in atomically thin MgB₂

J. Bekaert*, A. Aperis[°], B. Partoens*, P. M. Oppeneer[°], and M. V. Milošević*

* Department of Physics, University of Antwerp, Groenenborgerlaan 171, B-2020 Antwerp, Belgium.

[°] Department of Physics and Astronomy, Uppsala University, Box 516, SE-751 20 Uppsala, Sweden.

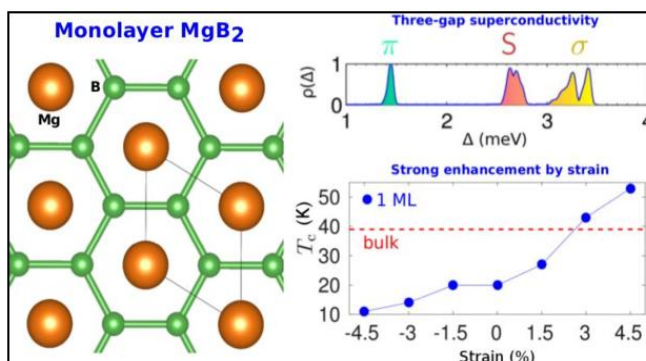
Contact: jonas.bekaert@uantwerpen.be

To date, little is known about how the superconducting state changes when a material is gradually made thinner, towards the monolayer limit. This is especially the case for multigap superconductors, hosting multiple condensates linked to different electronic states.

Here, we combine first-principles calculations of the electronic properties, vibrational modes and electron-phonon interaction with anisotropic Eliashberg theory, to study the evolution of multigap superconductivity in the atomically thin limit. We prove that magnesium diboride (MgB₂) — a widely studied two-gap superconductor in its *bulk* form — radically changes to a distinctly three-gap superconductor in *monolayer* form, under the influence of an emerging surface state [1,2]. We demonstrate for the first time that such two-dimensional multigap superconductivity can be tailored on the atomic scale. Firstly, the interaction between the superconducting condensates is strongly altered when adding monolayers to the film, which can be exploited to make truly nanoscale superconducting junctions, by spatially varying the film thickness [1,2].

Furthermore, we show that the critical temperature of superconductivity in monolayer MgB₂ can be greatly enhanced, from 20 K to above 50 K, by applying a rather modest amount of tensile strain [1]. This strain-enhancement, while preserving the three-gap nature of superconductivity in monolayer MgB₂, is stronger than in any other two-dimensional superconductor known to date. Seeing that the guiding principle behind the enhancement is generally valid for many two-dimensional materials, we expect broad applicability of this finding.

Finally, we show an experimental validation of the predicted superconductivity of the surface state electrons, by means of recent low-temperature ARPES measurements on few-monolayer MgB₂ [2].



[1] J. Bekaert *et al.*, Physical Review B **96**, 094510 (2017).

[2] J. Bekaert *et al.*, Scientific Reports **7**, 14458 (2017).