PhD thesis topic

Mathematical models of hybrid materials

doc. Mgr. David KREJČIŘÍK, Ph.D., DSc. *

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Traditional conductor or semiconductor materials have been successfully described by the mathematical formalism of non-relativistic quantum mechanics for more than the last hundred years. Artificial materials of graphene type requires the formalism of relativistic quantum theory and their rigorous investigations appeared in this millennium only.

What is more, there are current experiments with hybrid materials which share mathematical aspects of both. Among those, let us mention semi-Dirac semi-metals, which behave like a conventional zero-gap semiconductor material in one direction and graphene in the orthogonal direction [2, 5]. However, their systematic mathematical investigation is missing.

The objective of this PhD project is to fill in this gap by developing a rigorous theory of hybrid materials, notably of the semi-Dirac semi-metals. The starting point is to investigate the stability issues in the spirit of the pioneering work [3]. The student will establish sufficient conditions which guarantee the stability of the essential spectrum and the existence/absence of discrete eigenvalues. Further dependence of the eigenvalues on electromagnetic or geometric interactions will be derived by unconventional perturbation techniques [4]. Non-Hermitian models [1] will be considered, too.

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References

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*Department of Mathematics, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University in Prague; e-mail: david.krejcirik@fjfi.cvut.cz.