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Reviewer's report on the Doctoral Thesis "Charge transport in semiconductor nanostructures investigated by time-resolved multi-terahertz spectroscopy" submited to Universita Karlova by Mgr. Jiří Kuchařík

This work has many possible applications in the field of THz science itself and in various areas, since it helps to understand how THz radiation interacts with matter. The reason for this is that many substances exhibit rotational and vibrational transitions in the THz range, hence giving access to a spectroscopic analysis of a large variety of molecules which play a key role in security, air pollution, climate research, industrial process control, agriculture, food industry, workplace safety and medical diagnostics can be monitored by sensing and identifying them via THz and mid infrared (MIR-15 THz to 120 THz) absorption "finger prints". Most plastics, textiles and paper are nearly transparent for THz radiation. From the fundamental science point of view, interesting physical properties, such as nonlinear phenomena, only recently started to be analysed, after sufficiently powerful THz sources have been developed. The progress is very fast and many effects have been and are currently under investigation, but still far less knowledge is available, than for instances in the visible and near infrared ranges.
Most of this thesis covers the development of theoretical tools to investigate the linear and nonlinear response of semiconductor nanostructures in the THz range and the results and interesting and timely.

The thesis starts with an introduction, followed by the (1) response to electromagnetic radiation, (2) Monte-Carlo calculations of conductivity, (3) wave propagation in linear media followed by a (4) nonlinear media analysis. Next the (5) THz Linear conductivity of a confined electron gas is studied followed by the (6) THz Nonlinearities in 1D and then 7. Semiconductor nanostructure case. This is complemented by (8) THz spectroscopy of TiO2 nanotubes, followed by Conclusions, Appendices, References, a list of publications and of symbols used throughout the text.

The original results of the thesis, with corresponding publications highlighted were due are given in sections 2.2, 4. 5.2-5.5, 6, 7 and 8.3-8.5. Among these, I can highlight the predicted characteristics THz conductivity of inhomogeneous media, time-domain THz spectroscopy to study the dielectric, percolation and photoconductive properties of

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various self-organized TiO_2 nanotube layers.

In conclusion, most of the results have been published, which means that even before this evaluation, the results survived the serious scrutiny of several referees in serious journals such as Physical Review B and as a search in the literature shows, even the SPIE Proceedings correspond to an Invited Talk at the SPIE Meeting in San Diego, further confirming the immediate impact of this work. The introduction and extended discussion of the material along the thesis make it easier for the reader to connect the dots between the publications and fully understand their interconnected relevance. I fully support this thesis to be defended, since it clearly proves the author's ability for relevant, serious and creative scientific work.

In addition I have the following questions:

1. Both semiclassical and quantum approach basically consider free electrons, so how would you consider extending the approach to add the Coulomb interaction and many body effects for future studies? What would be your initial approach to describe the more complex problem?

2. The electron gas has been studied in infinitely deep rectangular wells. Would you comment on how you would handle the case of more realistic quantum well , wires, superlattices and quantum dots, where finite potentials and dimensions must be considered, beyond e.g. the elliptically curved segments of Section 5.4 or the harmonic potential of Section 8.3.1 for the nanotubes?

Prague, 12.09.2019, Prof. Dr. Mauro Fernandes Pereira