Review Report on PhD Thesis

Faculty: Central European Institute of Technology Academic year: 2021/2022
Brno University of Technology in Brno

Student: Ing. Antonín Sojka

Doctoral study program: Advanced Materials and Nanosciences

Field of study: Advanced nanotechnology and microtechnology

Supervisor: doc. Ing. Petr Neugebauer, Ph.D.

Reviewer: Associate Professor, Dr. Mark Tseytlin

PhD thesis title: Development of a Novel Terahertz Magnetic Resonance Spectroscopy for Spin Dynamics Investigations

Topicality of doctoral thesis:

High-field electron paramagnetic resonance (HFEPR) is a rapidly developing area of research with a wide range of applications. On one end the applications are biomedical sciences. HFEPR is a potent tool in the studies of the structure and dynamics of biological macromolecules. The use of strong magnetic fields permits acquiring spectroscopic information not attainable by conventional/commercial EPR instruments. On the other end of HFEPR use are material sciences. The properties of nanomaterials, such as nanomagnets and nanodiamonds, are investigated using EPR at high magnetic fields and/or frequencies.

In this Ph.D. thesis, Antonin Sojka addresses the problem of both instrumentation and method development for high field EPR. His has been a significant contribution to the success of the spectrometer built in Brno. Among other parts, he designed and tested several unique types of sample holders. He also has contributed to the development of Frequency Rapid Scan EPR.

Meeting the goals set:

The goal stated in this thesis has been "to design, build, and troubleshoot a novel resonance-free high-frequency/high-field EPR spectrometer that is able to operate at the same time in frequency and field domain and advance the frequency-domain rapid scan technique at high frequencies". In my opinion, this goal has been achieved as evident from the thesis itself and related publications. It is obvious that Antonin's contribution has been significant. However, his part in the overall development of the instrument is not clearly distinguished from those of the others.

Problem solving and dissertation results:

Antonin demonstrated truly innovative engineering approaches to the design of the HF EPR spectrometer in general, and the sample holder, specifically. He mastered the use of complex modeling software that greatly facilitated his work and points to his advanced problem-solving skills. Various numerical simulations and test measurements culminated in the acquisition of the RS EPR signal confirmed the validity of the results described in this thesis.

Importance for practice or development of the discipline:

The detailed description of the spectrometer designs and experimental results will no doubt be very useful to the EPR community in general and practically helpful to the developers of EPR instruments and methodologies, specifically. HF EPR is a novel field with a lot of unknown factors and challenges that are yet to be recognized and eventually solved. I believe, that Antonin's work, his know-how, trials & errors described in this thesis and related publications will be highly valuable for the researchers and developers of high field EPR.

Formal adjustment of the thesis and language level:

I would recommend carefully reading the document and removing some of the typos and confusing wording within the text. Other than that, the manuscript is easy to read and comprehend.

Questions and comments:

Overall in the text, the margins/formatting is not consistent.

Page 1. The first definition of the Zeeman effect needs to be corrected. It has nothing to do with EM waves. However, in the following sentences, the description is correct.

Page 2. I would rephrase: " for the determination of distances inside the cells or proteins "

Page2/3. Need to mention the major advantages of RS EPR: (1) fast data acquisition (2) sensitivity gain

Page 9. Can you explain why "The oversized components for high m.w.frequencies would have meters in diameter; "

Page 11. The Czech Republic was never part of the USSR.

Page 18. Can you explain: "An FDMR measurement has a big advantage over the MDMR in that the energy spectrum is directly recorded, while in MDMR, the peaks corresponding to the highest energy are recorded first."

Page 32. "$T_2 = 0$" is not very scientific description

Page 35. Strictly speaking, T2* is measured in the RS experiment, not T2, the latter can be simulated.

Page 40. Fig.1. Why attenuator is used on the LO side?

Page 41. In "The m.w. generated in RF source", I would stay with commonly accepted definitions: Radiofrequency (RF) and microwave (MW) radiation are electromagnetic radiation in the frequency range 3 kilohertz (kHz) - 300 Megahertz (MHz), and 300 MHz - 300 gigahertz (GHz), respectively

Page 43. Magnet instability does not generate 'noise in spectra' as much as broadens the EPR line, in my opinion. Can you explain the experiment and what you observe?

Page 97. Fig 6.1. The spectra do not look like RS EPR. Are they RS?

Page 101. Fig 6.3. The 'wiggle' pattern has a 'bump' at the end. Why?

Page 105. In "that LiPc acts like a 1-D organic conductor with the slowest". . What is the effect of conductivity?

Page 105. Why did you dissolve BDPA vs. using a nitroxide?

Conclusion:

The results of this work will no doubt advance the field of high-frequency EPR, including instrumentation and applications. Antonin has owned the right to be called Dr. Sojka. I would recommend, if possible, going over the text and figures and fixing some typos and confusing wording.

In my opinion, the reviewed thesis **fulfill** all requirements posed on theses aimed for obtaining PhD degree. This thesis **is ready** to be defended orally, in front of the respective committee.

Date: April 3rd, 2022; Morgantown, WV, USA

.....Prof. Mark Tseytlin ...

name of the opponent

CEITEC – Středoevropský technologický institut
Vysoké učení technické v Brně

Purkyňova 123, 612 00 Brno, Česká republika

www.ceitec.cz