

Review report on habilitation thesis by Dr. Marco La Mantia: Particle dynamics in quantum turbulence

Habilitation thesis by Dr. Marco La Mantia presents the main results which the applicant has achieved during his work at the Department of Low Temperature Physics, Charles University, since October 2009 in Prague. The thesis is based on a collection of 12 scientific articles focused on the study of quantum turbulence, mostly in superfluid 4He , including the development of experimental techniques. I would like to highlight two main achievements of the applicant: (I) experimental achievement – his important contribution to establishment of the first low temperature cryogenic flow visualization laboratory in Prague as well as in Europe, the laboratory which he is currently in charge of, and (II) achievement in physics - using this above mentioned experimental facility and technique to investigate and to extend our knowledge on quantum turbulence in superfluids, in particular, the study of the crossover between quasi-classical and quantum turbulent regimes in superfluid 4He .

Design, construction and tuning of this visualization laboratory had to cost the applicant tremendous amount of time, work and effort. Starting from design of the cryostat with optical access along with design and construction of the cryogenic seeding system delivering visualization particles (solid hydrogen and deuterium), the development and testing of the software for analyzing recorded movies with aim to distinguish individual particles and follow their trajectories in time, performing water testing experiments of the visualization system, etc.. This is a list of the tasks that the applicant had to solve. These tasks have been solved by him successfully, and finally led to establishment of the first low temperature visualization laboratory not only in the Czech Republic but in Europe.

By establishing this visualization laboratory, according to my opinion, Dr. La Mantia has justified his experimental skills, autonomy and scientific independence. I need to emphasize, however, that this achievement would not have been possible without “foundation bricks” put by prof. RNDr. Ladislav Skrbek, DrSc. many years ago. New experimental technique opens new avenues in physics and provides new challenges. Attached scientific articles are justification of this statement and I am sure that this is only beginning.

Regarding to academic (or teaching) activities: Dr. La Mantia is in charge of two graduate courses (fluid turbulence and flow visualization), he is supervising the PhD. and undergraduate students. He has also started to be active on international and national level by establishing the collaboration with partners, e.g. the Institute Neel, Grenoble (France), the Royal Melbourne Institute of Technology (Australia) and the Institute of Scientific Instruments (Czech Republic). I am sure that this is only a starting point of his activities in various scientific and academic domains, which will be gradually extended and expanded.

Let me briefly comment a formal aspect of the habilitation thesis. I am (more or less) a specialist in various fields of low temperature physics and for me it has not been any problem to understand main results presented in thesis. However, I wonder if a non-specialist could understand the topic of quantum turbulence and its visualization problem. This is the habilitation thesis, and I think that some short introduction into superfluidity of helium-4, how the energy spectrum looks like, what kind of the excitations – sounds-like quasi-particles - can be generated in He-II, ... finishing, let say, with explanation of the origin of quantum turbulence in He-II and the importance of its investigation, should be written at the beginning of the thesis. And some figures demonstrating the physical

properties of the helium-4 would be very useful, informative and educational. This is what I have missed in the thesis. My comment is not meant to decrease the scientific level of the thesis – which is very high; it is rather a general comment to its formal aspects – whether Charles University has some formal template instructing how the content of the habilitation thesis should look like.


As an important part of the habilitation lecture is a discussion, let me ask the applicant a few questions:

- The camera takes pictures of the visualization particles in two dimensions (with some focus depth). However, in reality these particles move in three dimensions. How do you see this problem?
- You have developed excellent visualizing experimental technique to study turbulence in general. As any experimental technique – your technique has also some limits. In this context I would like to ask your opinion - where are the limits of this experimental technique, and whether these limits can be pushed further and what needs to be done for that?
- Regarding to experimental technique I would like to ask you a speculative question. Particles you use for detection carry magnetic moment. Based on your experience, how could you comment the idea to use MRI technique for “visualization” of the turbulence?
- Let me ask one pedagogical question. As you know, the vortices can be generated in the superconductors as well. What are common like physical properties of the vortices generated in quantum liquids and superconductors, and what makes them completely different?
- What do you consider to be the main challenging problems that need to be solved in quantum turbulence in general, or in other words – according to your opinion, what is the future of the research in quantum turbulence, and particular in your laboratory in Prague?

In conclusion, I would like to declare that the habilitation thesis by Dr. Marco La Mantia: **Particle dynamics in quantum turbulence** has a high scientific level, scientific results presented in the thesis are actual and they extended our knowledge on quantum turbulence. Results have been published in internationally accepted scientific journals and there are sufficient numbers of scientific citations on them. I can also state that the number of published scientific articles (37 according to the WoS database) together with the number of citations (almost 200 citations) is significantly higher than the numbers recommended by the Scientific Council of the Faculty of Mathematics and Physics of Charles University.

I recommend this thesis to the Habilitation Committee at the Faculty of Mathematics and Physics of Charles University as a work that fulfills all requirements for habilitation and I support the nomination of Dr. Marco La Mantia for the Lecturer (Docent).

Košice, June 20th, 2018


RNDr. Peter Skyba, DrSc.