Comenius University in Bratislava
Faculty of Mathematics, Physics and Informatics

THESIS ASSIGNMENT

Name and Surname: Jakub Bahyl
Study programme: Physics (Single degree study, bachelor I. deg., full time form)
Field of Study: Physics
Type of Thesis: Bachelor´s thesis
Language of Thesis: English
Secondary language: Slovak

Title: Measurement of Quantum Turbulence in Superfluid 4He Using Second Sound Attenuation

Aim: During the work on this Thesis, the student will become familiar with the theoretical foundations of the description of quantum fluids and superfluidity. The student will learn about several experimental methods used for characterization of the flows of superfluid helium, such as second sound attenuation, which differs significantly from any techniques used in classical fluids. Given the focus of the Thesis, classical hydrodynamics will be used as a stepping-stone to help in the understanding of quantum fluids. On the practical side, the student will learn to design and run complex cryogenic experiments. This work will cover a wide range of skills, starting with the understanding of safety procedures for handling cryoliquids, of specific measures needed for operation of experiments with liquid helium at temperatures between 1.2 K and 4.2 K, and including work with sensitive electronic detectors such as quartz tuning forks, as well as a fundamental understanding of modern automated data acquisition and processing.

Literature:
[1] L.D. Landau, E.M. Lifshitz, Fluid Mechanics, Pergamon Books, 1987
[2] L. Skrbek a kol., Fyzika nízkých teplot, Matfyzpress, 2011
[3] D.R. Tilley, J. Tilley, Superfluidity and Superconductivity, Adam Hilger, 1986
[4] R.J. Donnelly: Quantized vortices in helium II, Cambridge University Press, 2005
[5] E. Varga, S. Babuin, L. Skrbek, Second-sound studies of coflow and counterflow of superfluid He-4 in channels, Phys. Fluids 27(6), 065101 (2015)
[6] Vinen, W. F. Mutual friction in a heat current in liquid helium II. II. Experiments on transient effects. Proceedings of the Royal Society of London A: Mathematical, Physical and Engineering Sciences. 240, 1220 (1957).
[7] R. Blaauwgeers, M. Blažková, M. Človečko, V.B. Eltsov, R. de Graaf, J. Hosio, M. Krusius, D. Schmoranzer,W. Schoepe, L. Skrbek, P. Skyba, R.E. Solntsev, D.E. Zmeev: Quartz Tuning Fork: Thermometer, Pressure- and Viscometer for Helium Liquids, J. Low Temp. Phys. 146, 537-562 (2007)
[8] S.L. Ahlstrom, D.I. Bradley, M. □love£ko, S.N. Fisher, A.M. Guénault, E.A. Guise, R.P. Haley, O. Kolosov, P.V.E. McClintock, G.R. Pickett, M. Poole, V. Tsepelin, and A.J. Woods, Phys. Rev. B 89, 014515 (2014).

Annotation: The main focus of this Thesis will be study of oscillatory flows of superfluid helium at low temperatures. Specifically, we will characterize the transition to

turbulence in a flow due to an oscillating tuning fork, combining, for the first time, two different methods simultaneously. The first technique will rely on standard drag force measurements performed using the tuning fork, while at the same time, second sound attenuation will be used to determine the density of quantized vortices in the flow. The principal question we will tackle is whether classical turbulence and quantum turbulence form at the same time in the given flow, or whether they can be observed separately in a subset of the parameter space defined by the tuning fork velocity and an effective Reynolds number. This work is directly related to ongoing research at the Laboratory of Superfluidity operated by the Faculty of Mathematics and Physics of the Charles University in Prague.

Supervisor: David Schmoranzer
Rektorát, dekanát: FMFI.Dek - Faculty Administration

Assigned: 29.10.2015

Approved: 29.10.2015 prof. RNDr. Jozef Masarik, DrSc.
Guarantor of Study Programme

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Student

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Supervisor