Posudek práce

předložené na Matematicko-fyzikální fakultě Univerzity Karlovy v Praze

☐ posudek vedoucího ☑ posudek oponenta
☐ bakalářské práce ☑ diplomové práce

Autor/ka: Bc Emil Varga
Název práce: Steady state and decay of quantum turbulence generated in channel flows and detected by second sound attenuation
Studijní program a obor: Fyzika, Fyzika kondenzovaných soustav a materiálů
Rok odevzdání: 2014

Jméno a tituly vedoucího/oponenta: Professor William F. Vinen, F.R.S., Dr.h.c.
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Odborná úroveň práce:
☒ vynikající ☐ velmi dobrá ☐ průměrná ☐ podprůměrná ☐ nevyhovující

Věcné chyby:
☒ téměř žádné ☐ vzhledem k rozsahu přiměřený počet ☐ méně podstatné četné ☐ závažné

Výsledky:
☒ originální ☐ původní i převzaté ☐ netriviální kompilace ☐ citované z literatury ☐ opsané

Rozsah práce:
☒ veliký ☐ standardní ☐ dostatečný ☐ nedostatečný

Grafická, jazyková a formální úroveň:
☒ vynikající ☐ velmi dobrá ☐ průměrná ☐ podprůměrná ☐ nevyhovující

Tiskové chyby:
☒ téměř žádné ☐ vzhledem k rozsahu a tématu přiměřený počet ☐ četné

Celková úroveň práce:
☒ vynikající velmi dobrá ☐ průměrná ☐ podprůměrná ☐ nevyhovující

Slovní vyjádření, komentáře a připomínky vedoucího/oponenta:
The thesis describes new and original experiments on quantum turbulence carried out by the author in which superfluid helium is forced to flow through a wide channel by compressing bellows attached to one end of the channel. As the helium flows into the channel it passes through a "flow conditioner", similar to that used in classical wind tunnels, in order to remove any large-scale eddy motion. Flow through the main section of channel can be either unimpeded or through a grid, so that the system is analogous to either classical pipe flow or classical flow through a grid. The quantum turbulence produced in a region about half way down the channel (downstream of any grid) is monitored by observing the attenuation of second sound propagating across the channel. Such a measurement measures an appropriate spatial average of the density of quantized vortex lines in the flow. Such measurements have been used in the past, but in types of flow different from those studied here. The aim is to provide experimental data with which to compare the predictions of theoretical models of the appropriate forms of quantum turbulence.

These data take the form of the dependence of the steady state vortex density on flow velocity and of the dependence on time of a decaying vortex density following cessation of the flow.

The author has become expert in the quite complex experimental techniques required for this work. His measurements appear to be very reliable. He is clearly familiar with, and understands, the background literature. The experimental part of his thesis is very clearly written, in an unusually mature style. It reminds me of some of the best PhD theses that I have encountered. Indeed I have seen many successful PhD theses that are no better.

A substantial part of the thesis is devoted to the interpretation of the author's experimental results. His results on the decay of the turbulence are similar to those obtained with other types of flow, and here I am happy with the interpretation, which involves the determination of an effective kinematic viscosity that is related to the rate of dissipation of the quantum turbulence . The author explores a number of different interpretations of his steady-state results, and he comes down in favour of one (Section 3.1.2) that is, in my opinion, probably along the right lines. The suggestion is made that these steady-state results can also yield values of the effective kinematic viscosity, although with less confidence. But here there are problems. It is assumed, without comment, that the length scale H is determined by the mesh size of the grid or of the flow conditioner, and that it remains constant as the flow proceeds downstream. This is a questionable assumption and seems inconsistent with the effective growth in time of the size of the energy-containing eddies in decaying turbulence described in Section 3.1.1. A resolution of this problem might require further experiments, with a range of sizes of the grid mesh.

A final section in the thesis describes an interesting and original theoretical analysis of the effect of a spatially inhomogeneous vortex density on the different normal modes of the second sound resonator.

Overall I see this thesis as describing very clearly an impressive programme of publishable experimental work, much more than adequate for the award of a master's degree. The discussion of the experimental results is perhaps slightly less impressive, but is still more than adequate. The overall quality of the writing and presentation is very high.

Případné otázky při obhajobě a náměty do diskuze:

1. In liquid helium at zero temperature what fraction of the atoms is in the condensate? Is this fraction the same as ρ_s/ρ? If not, why not?
2. Why is a dc voltage applied to the second sound transducers?
3. What important role is played by remanent vortices in quantum turbulence?
4. Values of the effective kinematic viscosity are quite scattered. Is this scatter outside the probable experimental error, and if so why?
5. Why is it assumed that the eddy-containing eddies in the steady-state flow do not effectively grow in size as they move down the channel?

Práci
☑ doporučuji
☐ nedoporučuji
uznat jako diplomovou/bakalářskou.

Navrhuji hodnocení stupněm:
☑ výborně ☐ velmi dobře ☐ dobře ☐ neprospěl/a

Místo, datum a podpis oponenta: W.F. Vinen

Abu Dhabi, 04.05.2014 William F. Vinen