CEA - Saclay 91191 Gif-sur-yvette Cedex

Service de Physique de l'Etat Condensé

SÉMINAIRE

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Mercredi 20 juinl 11h15

Orme des Merisiers SPEC Salle Itzykson, Bât.774

Hot-wire measurements in a liquid 4He axis-symmetric jet

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Turbulence is an unsolved problem in fundamental physics that reverberates on engineering applications such as mixing enhancement in combustion, drag reduction in the automotive and aerospace industry and geophysical flow modelling. The re- search effort is focused on the measurement of the statistical properties of the energy cascade and dissipation process in fully developed turbulent flows in order to have a better estimation of the power law scalings in the inertial and dissipative length-scales ranges. Nevertheless deviations from the theoretical predictions have been extensively reported and attributed to not yet fully understood phenomena such as the statistical intermittency at small scales(1). From an experimental perspective a better understanding of these long standing issues requires an increase in the range of scales involved in the cascade process, from the injection scale L down to the dissipative Kolmogorov scale = LRe-3/4, where the power law scalings are expected. Among all the technical solutions that can be adopted to significantly increase Re (i.e. increase in the apparatus size, working fluid pressure and molecular weight) gaseous and liquid 4He at cryogenic temperatures (between 4.2 and 2.17 K) had proved to be a suitable working fluid to span the highest Re numbers ReL = UL/ with modest flow velocities U in a laboratory-scale apparatus(2) thanks to its low kinematic viscosity .

The objective of this lecture is to make the audience feel the challenges, hurdles and difficulties involved in performing turbulence experiments at cryogenic temperatures. After a brief introduction about the current experimental needs in term of high Re numbers controlled turbulent flows and the different ways to achieve this ultimate goal I will focus on the advantages and disadvantages of using cryogenic gaseous and liquid 4He as a working fluid. The superfluid nature of the liquid phase HeII at temperatures lower than 2.17 K will be briefly discussed with respect to the classical framework of developed turbulence (3).

In the second part I will focus on the different mechanical, thermal and hydraulic problems that intervene in the design of a cryogenic wind tunnel along with the solutions adopted. As example I will use a newly developed cryogenic liquid 4He facility specifically designed to perform high Re numbers classical and quantum turbulence experiments (4).

The third part is devoted to the cryogenic sensors. I will briefly describe the available state-of-the-art sensor capable to work at cryogenic temperatures before focusing on the recent developments in hot-wire anemometry. Preliminary results obtained in an axisymmetric jet at Re between 1000 and 2000 in He I and He II will be also presented. I will conclude with a prospective on the future experimental challenges.

1 Frisch, Turbulence, Cambridge University Press ; 2 Chanal et al., Eur. Phys. J. B 17, (2000) ; 3 Vinen et al., J. Low Temp. Phys. 128, (2002) ; 4 Duri et al., Rev. Sci. Instrum. 82 (2011)

A coffee break will be served at 11h00. The seminar will be given in English.

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