Foreword

This landmark book is a very welcome addition to the rapidly expanding literature dealing with large eddy simulation (LES). Its scope, the mathematical theory which underlies the LES technique for simulating incompressible turbulent flows, is certainly one of the most exiting rising issues in this field. It is worth remembering that thousands of papers have been published that are related to LES, most of them devoted to the presentation of new models for subgrid scales that are not resolved in the simulation or to the use of LES for flow dynamics analysis. Only very few papers address the fundamental issue of the theory of LES, which is to be distinguished from the usual closure problem. As a matter of fact, the mathematical theory of LES is still at its very beginning. A first issue is the derivation of a mathematical model for the scale separation between resolved scales and subgrid scales. The most popular model (but let us recall that it is nothing but a useful and limited model!) is certainly the convolution filter paradigm introduced by Leonard in the 1970s. The second issue is related to the properties of the selected mathematical model of LES: is it well-posed from a mathematical point of view? How regular are its solutions? Are they unique? These questions may seem to be uncorrelated from the practical purposes of most LES practitioners, but they are in fact central in most LES studies. A look at the existing LES literature reveals that a tremendous human and computational effort was devoted to empirical sensitivity analysis of the LES solution (changing the grid, the numerical scheme, the subgrid models) during the past decades, most of them yielding no clear conclusion. Here, the help of mathematicians is definitively needed, because only a rigorous mathematical analysis can lead to a non-controversial conclusion. As a general remark, we can also observe that many mathematical tools could be used to investigate the properties of LES. Chapter 5 of the book is a brilliant example, and I am sure that more and more powerful mathematical methods will enrich the LES methodology in the near future. Let us also remark that up to now, most of LES theory has been derived using low-level tools, such as convolution product and Taylor series expansions.

The authors are among the most famous researchers in the field of LES mathematics. They succeed in the tremendous task of providing a general, non-specialized audience with the main mathematical results, without losing the required rigor. The result is this outstanding piece of work, which will be useful to all scientists, engineers and students interested in LES. The mathematical theory of LES is still a very young field, but let us be confident in the fact that its impact on LES practice will grow exponentially. We just have to recall David Hilbert's epitaph:

Wir müssen wissen
Wir werden wissen[1]

to be sure that mathematics and functional analysis will be the cornerstones of the definitively required theory of LES.

Paris, March 2005 *Pierre Sagaut*

[1] We must know; we shall know

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