Preface

Rationality and *Asymptotics* are the two *main concepts* associated with the *Modelling* in *Fluid Dynamics,* which have completely changed our *look* on the *Understanding* of *Navier–Stokes–Fourier* (*NS-F) equations*, governing the *viscous*, compressible and *heat conducting Newtonian baroclinic* and *non-adiabatic fluid flow*s.[1]

This *Rational Asymptotic Modelling* (*RAM*) *Approach* have raised, on the one hand, further new interesting questions and potentialities for *Applied Mathematicians,* in their quest of rigorous existence and uniqueness results for the *Fluid Flow* problems.

On the other hand, this *RAM Approach* have opening up of new vistas for the derivation, by *Fluid Dynamicians,* various consistent simplified models related with *real stiff fluid flow* problems, as an *assistance* to *Numericians* embarked *on a computational simulations* of complex problems of engineering interest with the help of high speed computers.

In this book we touch (see, in particular, the *Chap. 6*) the "crucial" problem of a *practical* (rather than *formal*, *abstract*) "*Mathematics*" for a *consistent RAM Approach,* via a *"Postulate"* and, some "*key rules*" inspired from asymptotics.

This "*mathematics for the RAM"* is applied in a consistent way to modelling of various stiff problems of the: *aerodynamics (Chap. 7), Bénard thermal convection (Chap. 8)* and *atmospheric motions (Chap. 9)*.

The main lignes of the aims of this book are set out in the "*Prologue*", and in the "*Overview*" a brief outline of the events related with my rather long "*RAM Adventure*", during the years 1968–2009, is given.

The book is divided into *nine Chapters*, an *Epilogue*, a *list of References*, and a *Subject Index*.

In *Chap. 2*, the Newtonian (*Classic*) Fluid Dynamics is considered as a Mathematical-Physical Science and the reader can find in *four Sections* a *concise*

[1] These *NS-F equations* are, in fact, the equations usually named *"Navier–Stokes Compressible equations"* – and assumed often *barotropic equations*, by the Mathematicians !

material concerning the *main* theoretical *concepts* and *principles*, *equations* and associated *initial* and *boundary conditions*.

The *Chap. 3* is devoted to a *tentative description of a rational way* for the *obtention*, from *NS-F equations*, various *main model* equations and also to a *discussion* concerning their *nonuniform validity, near the initial time (*where the *initial data* are given) and *in the vicinity of a solid wall limiting the fluid flow* (where the *boundary conditions* for the *velocity vector* and *temperature* are given).

The *Chap. 4,* is entirely concerned with the application of *RAM Approach* for a *justification of Boussinesq model* equations, assuming that the *Mach number is a small parameter*.

The *Chap. 5* is an application of the *RAM Approach* to *large Reynolds numbers unsteady fluid flow*, which leads to a complicated *Five Regions Structure of unsteady NS-F full equations*.

The *Chap. 6*, is a central one and present a "*sketch of a Mathematical Theory for the RAM Approach*". As a basis for this "*practical*" Mathematics, in the realization of our *RAM Approach, the following "Postulate" is accepted as true, despite its simplicity:*

> If a leading order an approximate simplified model is derived from a NS-F fluid flow problem, then it is necessary that a RAM Approach be adopted to make sure that terms neglected in a such NS-F stiff problem really are much smaller than those retained in derived approximate simplified, no-stiff, leading-order consistent model problem.

The *Chap. 7*, is concerned with the two applications of the *RAM Approach* in "*Aerodynamics*". *First*, the derivation of a *through-flow model problem*, for a fluid flow in an *axial compressor*, when the *blades* in a row are *very closely* spaced. *Secondly*, the *low Mach number flow of a gas within a cavity* which is *changing* its *shape* and *volume with time*.

In *Chap. 8, The RAM Approach* concerns the famous *Bénard convection problem for a liquid layer heated from below*. In particular, the following *alternative* is demonstrated:

> Either the buoyancy is taken into account, and in this case the free-surface deformation effect is negligible and we rediscover the classical leading-order Rayleigh-Bénard shallow convection, unless viscous dissipation, rigid-free, problem, or the free-surface deformation effect is taken into account, and in this case at leading-order, for thin films, the buoyancy and viscous dissipation effects does not play a significant role in the so-called Bénard-Marangoni thermocapillary instability problem.
>
> But, if you have intend to take into account, in the case of a deep liquid layer, the viscous dissipation effect – according to Zeytounian – in equation for the temperature, then it is necessary to replace, the Rayleigh-Bénard shallow convection equations, by a new set of equations called deep convection equations with a "depth" parameter."

The last *Chap. 9* is devoted to atmospheric motions. *First*, we derive for 2D steady *lee-waves problem*, in a baroclinic, non-viscous and adiabatic atmosphere, from the Euler atmospheric equations, a *single, exact but rather, awkward equation*. This equation, *coupled* with an exact relation for the *density*, prove to be very convenient for a *RAM Approach* of lee-waves starting problem, when we consider the *low Mach* number case. *Secondly*, the *low-Kibel/Rossby number* asymptotic model is considered, and a *global quasi-geostrophic* (G*QG*) model is derived from *NS-F hydrostatic dissipative atmospheric equations*. Namely: the *QG single main equation model*, *initial condition* (*at time = 0*) via an *unsteady adjustment (Adj)* and *matching*, and *boundary condition (at the flat ground*) via the *Ackerblom's problem in a steady Ekman boundary layer (Ek) problem* and *matching*.

In *Epilogue* some concluding remarks are sketched briefly.

A postgraduate Course may involve most of the contents of this book, assuming perhaps a working knowledge of a classical university fluid dynamics Course.

Short Courses for training Applied Mathematicians and Numericiens and young Scientists in Industry and Research Laboratories can also be based on most of the contents of this book.

In fact, the material in this book, it seems me, is primarily suitable (maybe indispensable!) for use by the Scientists and Research Engineers working in the fields of Fluid Dynamics and having as a main motivation the numerical simulation of very stiff complex real fluid flows.

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