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Aircraft trailing vortices/Tourbillons de sillages d'avions

Foreword

1. Introduction

The present volume aims to provide an overview of recent research conducted on aircraft trailing vortices (sometimes referred to as 'wake vortices' or 'wake turbulence'). This topic is characterized by an exceptionally-strong interaction between fundamental science and concrete engineering applications. Trailing vortices are an unavoidable byproduct of fixed-wing aircraft and can persist for many miles behind the vehicle. The imposition of trailing-vortex airplane-separation requirements in 1970 has been a catalyst for significant advances in vortex dynamics—a fundamental discipline at the crossroads of mechanics and physics. A heightened interest in the field came about in the 1990s, motivated by the need to improve airport throughput and by the introduction of the new Airbus A380. This has stimulated new studies seeking to predict and/or control the natural development of the vortices. Meanwhile, an increasing awareness of the potential impact of airplanes on the environment has motivated new research into the formation and persistence of airplane contrails. These various facets of the topic are covered in the present volume.

2. Organization of the volume

The volume starts with a short phenomenological introduction to aircraft trailing vortices [1]. The first three extended papers deal with fundamental aspects of trailing vortices. The paper by Jacquin et al. [2] details different aspects of the stability of the vortices which are relevant to the persistence, the merger, and the break-up of the vortices. Savaş [3] then reviews the experimental approaches developed to characterize these mechanisms in the laboratory. The paper by Meunier et al. [4] is concerned with the physics of vortex merging.

The two next papers are devoted to the numerical prediction of trailing-vortex wakes. The computation of trailing vortices requires a description of both the vortex sheet produced by the generator (an aircraft in the real world) and the development of this flow over a very long distance downstream. Currently, this entire flow field cannot be calculated with good fidelity using a single computational model. Several methods are thus needed, and are applied to different aspects of the problem. The paper by Czech et al. [5] describes the Reynolds Averaged Navier–Stokes (RANS) approach which provides satisfactory steady solutions of the flow in the near-field wakes of aircraft. The second computational paper by Winckelmans et al. [6] is devoted to more fundamental tools necessary to treat the far-field and the unsteady mechanisms of the flow in this region.

The next topic, which is also covered by two papers, is hazard alleviation by vortex control or avoidance. The paper by Crouch [7] describes possible control strategies based on the exploitation of vortex-instability mechanisms that may lead to premature break-up, and it provides evaluations of their potential benefit for reducing vortex-encounter upsets. The second paper, by Gerz et al. [8], presents an exhaustive reporting on advisory air-traffic control systems which are under development in Europe and in the USA. The systems are based on both vortex-tracking laser techniques and local meteorological forecasting.

The last two papers of the volume are devoted to trailing vortices in relation to environmental aspects of airplane wakes. The paper by Paoli et Garnier [9] focuses on the physics and chemistry of the interaction between the propulsive jets and the vortices, which may influence the formation and persistence of contrails. The paper by Schumann [10] considers the possible impact of the contrails on climate.

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