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Experiments on a helical vortex pair influenced by centrifugal instabilities

D. Schröder^a, T. Leweke^b and E. Stumpf^a

Results of an experimental analysis of various helical vortex configurations are presented. A one-bladed rotor, modified with a parametric fin to generate a system of two closely spaced helical tip vortices, is investigated in a recirculation water tunnel in the hover regime. This study aims at a fundamental physical understanding of the interactions of such vortex configurations, in order to explore mechanisms to reduce the negative effects of Blade-Vortex-Interactions (noise, unsteady loads) found in rotor operation. The properties of the vortex system, such as separation distance and circulations, can be influenced by the choice of the fin parameters (geometry, position). The initially separated vortices ultimately merge into a single vortex exhibiting an increased core radius and reduced velocity gradients, resulting in less severe interactions with a following blade, in comparison to an unmodified tip vortex. In previous studies^{1,2}, the presence of a centrifugal instability was observed, induced by a counter-rotating vorticity sheet related to the presence of the fin, and leading to a significant core growth for both vortices prior to the onset of the merging process. A subsequent volumetric analysis revealed the formation of secondary vortex structures adjacent to both cores during the growth phase, which are a consequence of the centrifugal instability. The characteristics and development of these structures and their effect on the pair were investigated in detail, the results are presented in this contribution.

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¹ Schröder et al., *CEAS Aeronaut. J.* **13**, 97-112 (2009).

² Schröder et al., *J. Phys. Conf. Ser.* **1934** 012007 (2021).

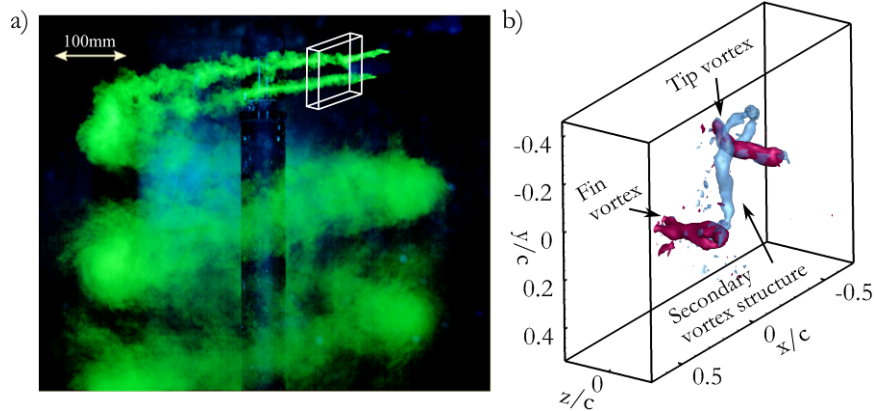


Figure 1: (a) Dye visualisation of the modified rotor wake¹. (b) Vortex structures obtained from tomographic PIV measurements, visualised using the Q-criterion.