Physics of Paragliding

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Résumé

Paragliding is a relatively young adventure sport introduced in the early 1980s involving flying lightweight, free-flying, foot-launched glider aircraft without a rigid primary structure. This design inherently leads to instability, particularly during unsteady phases of flight. While most research by paragliding manufacturers has focused on optimizing wing performance for steady flight, unsteady flight regimes remain relatively underexplored. In particular, many aspects of dynamic manoeuvres involving strong rotations remain poorly understood.
This study investigates the stability and dynamics of paragliders during spiral descent, a manoeuvre associated with significant safety risks. Spiral descent is characterized by the helical trajectory of both the pilot and wing around a shared axis. The manoeuvre poses unique dangers, as, even without brake action, the pilot can remain trapped in a continuous spiral configuration descending at approximately 20 m/s. In this configuration, pilots are subjected to strong centrifugal accelerations, which can lead to disorientation or even loss of consciousness.
By combining theoretical analysis and numerical simulations, this research explores the aerodynamic forces and their interplay with centrifugal and gravitational effects during spiral descent. The curved geometry of the paraglider wing induces complex aerodynamic forces and moments, which significantly influence the system's dynamic behaviour. A CFD-informed vortex lattice method is introduced, enabling the estimation of aerodynamic forces and moments on a paraglider wing with computation times far lower than those of full 3D CFD. Then, a stability analysis is performed to identify key parameters affecting spiral stability.

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