Motivation and Objectives

- Monarch Butterflies have the longest migration distance among insects at nearly 4,000 km. They can fly up to 200 km a day.
- During this journey they can attain altitudes of 1.2 km and overwinter in the Mexican Mountains at 3,000 m above sea level.
- The objective of this study is to understand the effects of high altitude on the flight of Monarch butterflies using optical tracking inside a large vacuum chamber.

Experimental Overview

- A 4 m long, 1.8 m diameter vacuum chamber is used to track free flight of Monarch butterflies.
- The chamber pressure and density can be controlled to simulate desired altitude conditions.
- Small reflective markers are placed on the wings and body of the butterflies and are remotely released inside the chamber.
- A motion capture system with 10 Vicon T40 cameras is used to track the motion of markers at 200 frames per second.

Results

- Lift Coefficient
  \[ C_L = \frac{L}{0.5 \rho V^2 S} \]
- Reynolds Number
  \[ Re = \frac{\rho VR}{\mu} \]

Conclusions

Results from 16 climbing flights indicate that:
- Reynolds number decreases with altitude
- Lift coefficient increases with increase in altitude.
- Flapping angle between the left and right forewing and flapping frequency nearly remain the same.

More detailed measurements and further analysis will be performed in the future to explain lift enhancement by flying at higher altitudes.

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