Study of the aerodynamics of biomimetic plumed seeds and their hypothetical dispersal on planets

Stage topic Description

Dispersal of seeds away from the parental plant is very important for diffusion and plants invest resources in a variety of structures specialized for this task. Wind dispersal is a particularly common strategy; many species rely on winged or plumed seeds to increase the efficiency of dispersal. The dispersal distance of a wind-dispersed seed is influenced by wind speed, the height at which the fruit is released, and the rate at which the seed falls to the ground. For this reason many plants evolved structures which decrease the terminal velocity of their seeds so that seeds can be spread out further.

The hair-like plumes (pappus) of many members of the Family Asteraceae act as a parachute, which slow their seeds' rate of descendant. But the scale up phase is quite delicate and to evolve larger seeds, a species would face challenging bio-mechanical problems [1][2]. If plume dimensions and seeds mass scaled isometrically then the plume loading would necessarily increase. Larger hairs would increase the bending moment and thicker hairs would decrease the drag. For this study we selected one species of plumed seeds, Tragopogon dubious (Nutt.), characterized by a large stalked pappus, probably the biggest parachute seed available in nature. The relative large size, its sturdy nature, and the hierarchical distribution of its pappy are already an example of how nature could increase the size of plumed seeds and provide a good subject for future biomimetic transfer [3].

The aim of the project is the development of an optimized structure, bio inspired by the parachute of the pappus-seeds and having a size able to support a payload, to be plunged into a planet's atmosphere. The parachute has the aim to maximize the time the payload will spend in the atmosphere before succumbing to the pressure and temperature or landing on the planet.

Candidate's tasks

The candidate's task will be to study the aerodynamic properties of plumed seeds. The work will be organized in several parts:

- Identify and write the appropriate aerodynamic equations on the base of morphological analysis and drop tests of the actual seed
- Determine the most suitable planet for deployment and develop a scale up mathematical model to support a payload
- Using the genetic algorithm, optimize the shape of the parachute (especially the distribution of primary and secondary hairs)

The ideal candidate

The candidate should have good knowledge of aerodynamics, structure and materials, Mathlab programming or similar software packages; computational fluid dynamics is an asset.

References

[1] Greene D. F., Johnson E. A. (1990) The Aerodynamics of Plumed Seeds. Functional Ecology, 4 (1) 117-125

[2] Minamia S., Azuma A. (2003) Various flying modes of wind-dispersal seeds. Journal of Theoretical Biology 225, 1–14

[3] McGinley M. A., Brigham E. J. (1989) Fruit Morphology and Terminal Velocity in Tragopogon dubious (L.).Functional Ecology, 3 (4), 489-496.