Thesis plan

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Contents

Chapter 1

Introduction

1.1 Swimming at the microscopic scale

1.1.1 The notion of swimming

1.1.2 What changes at the microscopic scale

Introducing the notion of low Re and its implication in terms of motion strategy

1.2 Concept of swimming through shell buckling

1.2.1 Presenting the swimming candidate

Say why it is a promising one and in which way is it different from the existing artificial micro-swimmers.

1.2.2 Introducing the mechanics of swimming

Guiding constraint: $P_c \propto E(\frac{d}{R})^2$
Swimming low Re necessary condition: check
Why we expect Inertial effects.

1.2.3 Experimental strategy

Up-scaling motives

Purpose: study the individual swimming =>
Why is it necessary? How is it relevant?
The non dimensional numbers to pay attention to (i.e the experimental parameters to be explored).

Material choice

Explaining what are the constraints in terms of deformation, tensile strength and why the pressure and $(\frac{d}{R})$ play a role in determining the range of rigidity. Why we chose elastomers? What does it imply? visco-elasticity

Chapter 2

Materials and methods

2.1 Spherical shell fabrication

2.1.1 Motivation

2.1.2 Why in-situ molding

2.1.3 Molding process

Molding equipments and materials

Molding process for for Dragon skin

Molding process for for AJO 121/122

2.2 Spring experiment

2.2.1 Brief introduction and motives

2.2.2 Equipments

Tank

Spring

Pressure controller

Cameras and lenses

2.2.3 Experimental process

1-D orientation

Lighting (concavity)

Experimental protocol

2.2.4 Image treatment

Image calibration due to window distortion

Contour extraction method (brief)

2.3 Frictionless rail

2.3.1 Brief introduction and motives

Talk briefly about the idea of the first try with the disc trapped between two non miscible liquids with different densities.

2.3.2 Equipments

Rail and air bearing

Liquids and water/glycerol mixing protocol

Support design

Pressure control

Cameras and lenses

2.3.3 Experimental process

Introduction of the imperfection on the spherical shells

Experimental protocol

2.3.4 Image treatment

Present briefly the algorithm to obtain positions.

2.4 PIV measurements

2.4.1 Brief introduction and motives

2.4.2 Equipments

Tank and support

Particles

Laser

Cameras and lenses

2.4.3 Experimental process

Chapter 3

Results

3.1 Thrust comparison between spring/rail experiments

3.1.1 Motives

3.1.2 Thrust extraction from spring

Buckling

glycerol, water and air for different $(\frac{d}{R})$

Unbuckling

glycerol, water and air for different $(\frac{d}{R})$

3.1.3 Thrust extraction from rail

Buckling

as function of the viscosity for different $(\frac{d}{R})$

Unbuckling

as function of the viscosity for different $(\frac{d}{R})$

3.1.4 Comparison of results and discussions

3.2 Swimming characterization

3.2.1 Swimming for $(\frac{d}{R})$

3.2.2 Swimming for different dissipation coefficients

3.2.3 Swimming near a wall

3.3 PIV measurement

3.3.1 Characterization of the flow in water and glycerol

3.3.2 Characterization of the flow for different $(\frac{d}{R})$

3.3.3 Understanding the swimming mechanics

Linking the results of the rail experiments to the flow results by PIV and discussing it.

Chapter 4

Conclusion

4.1 What to expect at the microscopic scale

4.2 What's next?

Experiments

Interaction of swimmers

Effect of the control frequency

Swimming in visco-elastic liquids

Swimming at the surface

Temperature-driven swimmers

Mixing through shell buckling

4.2.1 Numerical simulations

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