Keio University

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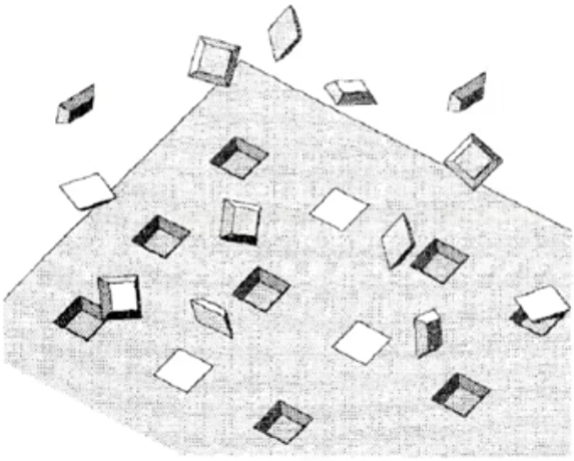
Onoe Hiroaki & Takahashi Hidetoshi's course - 2020

Biomimetic Micro/Nano Engineering
Report 3



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Academic year 2019-2020
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1 Introduction

Self-assembly systems are originally created in the nature. Basically, those systems consist of elements initially disordered that, because of physical phenomena of interactions between the elements, end up forming an organised structure or pattern. It is very interesting to study those process in the nature as it becomes possible to replicate the process to form complex structures that are still hardly understood by science. Self-assembly systems can be static (in equilibrium, not moving) or dynamic (animated). Besides, those are characterised by four main factors : the components with structures, the binding force, the environment and the driving force.

2 Assignment 1

2.1 Illustrate the meniscus between two bubbles and explain why they are attract to each other.

Figure 1 represent the meniscus force on one and then two bubbles. The blue force is the total surface tension. The green force represent the force perpendicular to the surface's plane while the red one is the force parallel to the surface's plane.

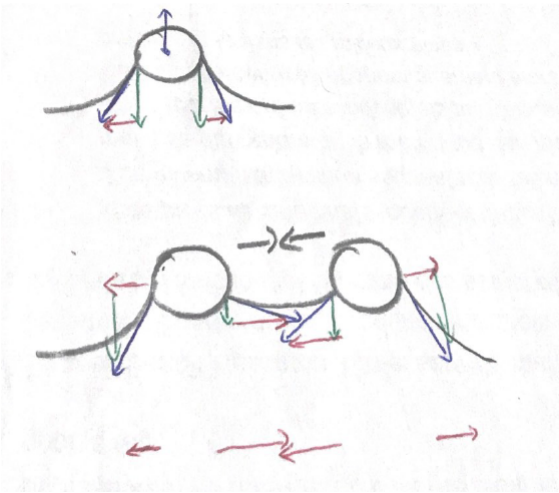

Figure 1: Meniscus on one isolated bubble, on the top. Meniscus between two bubbles on the bottom. The blue force is the total surface tension. The green force represent the force perpendicular to the surface's plane while the red one is the force parallel to the surface's plane

As can be seen at the bottom part of 1, while two bubbles get close to each other, the profile of the surface between them is modified, as a result the surface tension force is also modified and the vector points, between the two bubbles, in another direction compare to the initial isolated bubble. As a result of this new direction, the amplitude of the horizontal and vertical components of the meniscus force is modified. As can be seen in red at the very bottom of figure 1, the two forces attracting the bubbles, located between the bubbles and pointing in the direction of the other bubble, are greater than the two forces repelling. Therefore, the two bubbles finally stick to each other.

2.2 Illustrate the meniscus between two floating metal plates (heavier than water, hydrophobic) and explain what does happen between them.

Figure 2 represent the meniscus force on one and then two metal plates. The blue force is the total surface tension. The green force represent the force perpendicular to the surface's plane while the red one is the force parallel to the surface's plane.

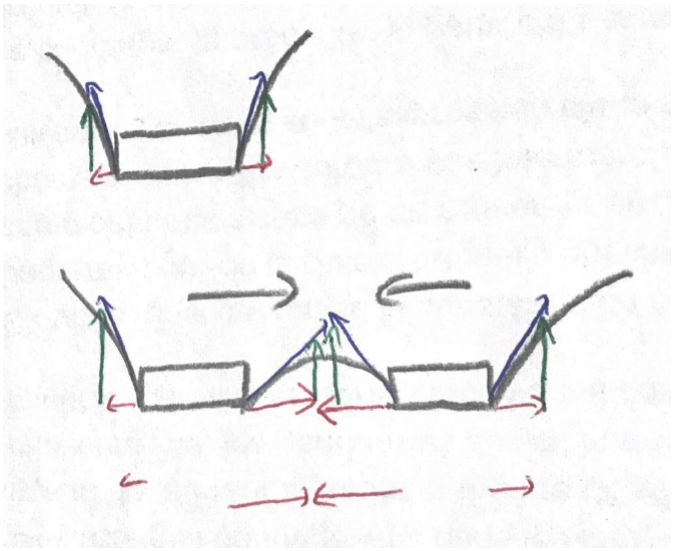

Figure 2: Meniscus on one isolated metal plate, on the top. Meniscus between two metal plates on the bottom. The blue force is the total surface tension. The green force represent the force perpendicular to the surface's plane while the red one is the force parallel to the surface's plane

Here, an hypothesis is made, the plates are brought close enough to each other so that the surface's profile is the one corresponding to the one displayed in the bottom part of figure 2. Again the description is such that the surface tension force is also modified and the vector points, between the two bubbles, in another direction compare to the initial isolated plate case. And again, as can be seen in red at the very bottom of figure 2 the two forces attracting the plates, located between the them and pointing in the direction of the other, are greater than the two repelling forces. Therefore, the two plates finally stick to each other.

2.3 What does happen when the bubble and the metal plate are close to each other?

In this case, the situation is different. The system created by the interaction of one bubble and one metal plate is displayed on figure 3.

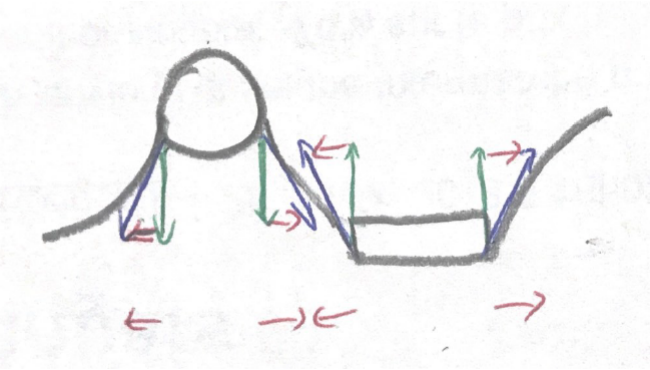

Figure 3: System created while a bubble and a metal plate interact with each other. The green force represent the force perpendicular to the surface's plane while the red one is the force parallel to the surface's plane

The bubble and the metal plate get close to each other. At this moment, because the bubble is lighter than water and the metal plate heavier the surface's profile is different from the previous case, the surface cannot just be at the same level between the two objects. The bubble is therefore located higher and the plate lower as observed on

figure 3. Due to this, the surface's profile between the object has a particular shape. The horizontal forces acting on each object have the same magnitude in both direction resulting in a null net force. Therefore, the object don't tend to really attract nor repel each other. So either it is a standing situation or either if the two object get really close, the surface changes again and the total force repelling the object becomes larger.

3 Assignment 2 : Choose and explain one self-assembly phenomenon around you.

A self assembly system that can be observed around me is "people studying". In the dormitory, once someone is studying, usually several people join and start to study together to be more concentrated.

In this case, the components are the individual students. The environment in which those students are present is a dormitory, and more precisely, a lounge or study room in the dormitory, a 3D structure. The random driving force is the fact that people randomly see other studying a therefore come to join, so the random movement of student in the dorm and if they need to study or not. Then, the binding force is the local interactions of student studying together, the students bind because those have to study. The more the student have to study, the more they stay together (the more they bind). Because they bind, the students see their behavior change, they are more quiet, are more focused, they can help each other, share common information. Finally, the energy is the time spent studying for the students. Of course, as usual, the energy is minimized, here it means they want to minimize the time they study and finish they work faster. By joining the group they can be more focused and not disturbed so more efficient also by helping each other they can spend less time.

4 Conclusion

In this report, the static, self-assembly systems where introduced. Cases of assembly of bubbles and metal plates on a liquid, due to the surface tension force, were investigated. Finally a self-assembly system of student in dormitory was chosen and explained.

References

[1] Onoe Hiroaki & Takahashi Hidetoshi's slides of "biomimetic micro/nano engineering" course. Course #3, slide #25.