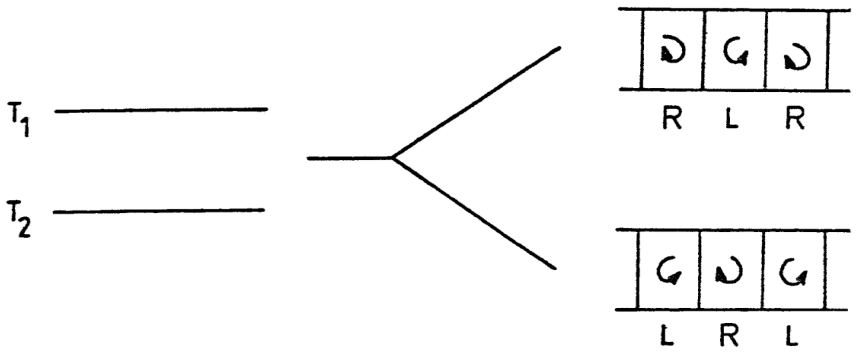
Climate change – Complexity

ID student: Activity 3

Benard Cells

1) As we discussed in the previous activity, the cross section of two neighboring magnetic fields constitute an unstable state which is called critical state. To what extent these critical states affect a system's final structure?

The following video presents the creation of characteristic cells, Benard cells, on the surface of silicon oil while it is warmed (based on a protocol developed by *(Stavrou & Duit 2014)*. In order to evidence the phenomenon, aluminum powder is added. As known, when a fluid is heated in a bowl, the warm masses at the bottom are moved towards the surface while the cooler upper masses are moved towards the bottom. This creates a rotating flow in the liquid either right-handed or left-handed *(Figure 1)*. Of course, this is not uniform for all the liquid. Therefore a portion of the liquid exhibits this rotation. When a portion of the liquid starts right-handed rotation a portion next to it starts a left-handed rotation and vice versa *(Figure 1)*.



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Grant Agreement n°2019-1-IT02-KA203-063184

Figure 1: a representation of the left-handed and right-handed rotation of the liquid (Stavrou & Duit, 2014)

Please watch the video and answer the following questions.

http://h5p.edthe.edc.uoc.gr/benard-cells/

2) What do you observe on the surface of the liquid?

3) Suppose that we repeat the experiment, to what extent do you think that the pattern of the Bernard cells would be identical?

4) Based on the representation below *(Figure 2)* , can you explain how the critical state of the initial flow's rotation leads to the final structure of the Benard cells pattern?

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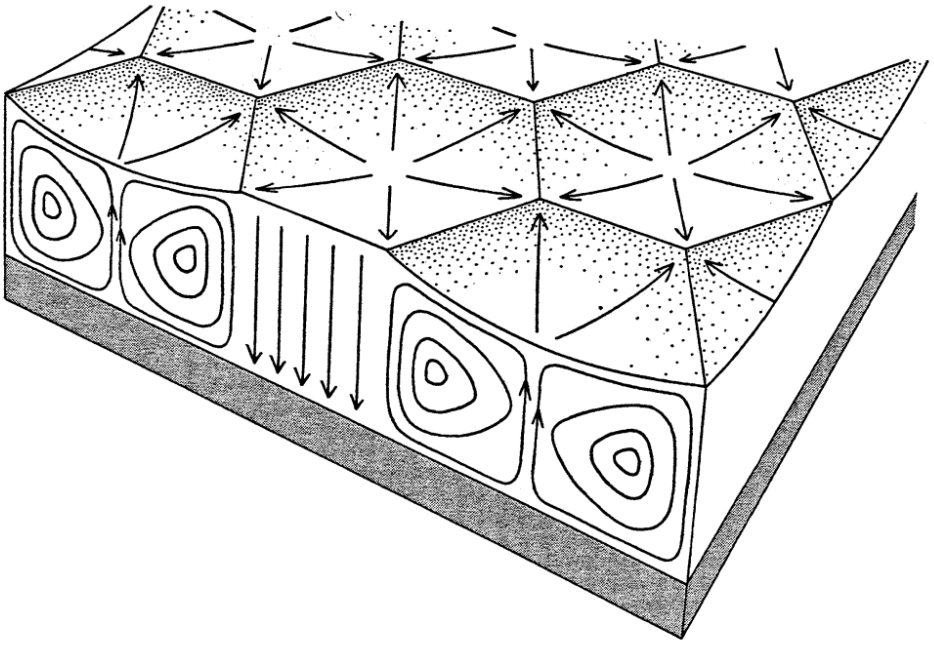

Figure 2: Representation of the meeting point of a left-handed and a right-handed rotation. (Stavrou & Duit, 2014)

You are provided with two blank tables *(Figure 3)* and markers of three different colors. Please draw with green color the initial flow of the liquid in any square you wish, either with a left-handed or right-handed vector. Then, design with blue color the surrounding cells considering that the horizontal and vertical neighboring cells should be filled by vectors with the opposite rotation (*Figure 1)*. Finally, having in mind the representations in *Figures 1 & 2*, please circle with red color only those pairs of rotation that form a Benard Cell. Follow the same directions for the second table except that design the initial flow in the exact same square of the table but this time following the opposite rotation than previously.

Table 1

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Table 2

5) Comparing the patterns appear on the two tables. How did the initial "critical state" of the rotation you chose determine the evolution of the "phenomenon"?

Reference

Stavrou, D. & Duit, R. (2014) Teaching and Learning the Interplay Between Chance and Determinism in Nonlinear Systems, *International Journal of Science Education*, 36 (3), 506-530

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