Some Instabilities

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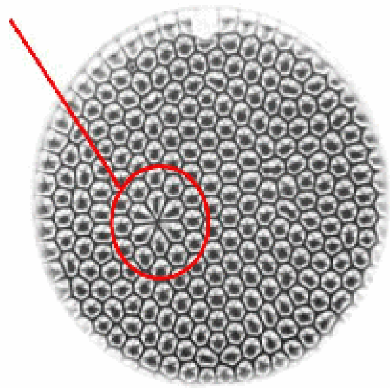
1. Reyleigh-Benard Convection Cells

From http://www.etl.noaa.gov/about/eo/science/convection/RBCells.html:

Rayleigh-Benard Convection Cells

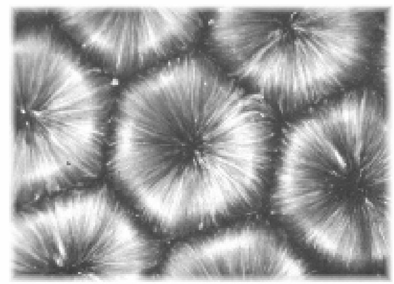
This type of convection pattern occurs in a relatively **shallow layer** - this could mean a layer of fluid 1 millimeter thick in a petri dish, or the first 2 kilometers of the Earth's atmosphere.

Perfect Conditions, Perfect Pattern (Almost!)



Under the right conditions, convection cells will take the shape of hexagons. Why don't we see hexagon-shaped clouds in the sky? Take a look at the picture to the right, and notice the small glitch in the pattern. It was later discovered that there was a tiny dent in the copper plate under the fluid. This tells us that the pattern is very sensitive to the bottom surface. Think about our earth - it's surface has millions of dents and bumps in the form of mountains, valleys, canyons, and more. All of these surface features affect the convection patterns in the atmosphere.

Fluid in Motion



This picture shows a time lapse view of Rayleigh-Benard cells. The picture was taken over ten seconds, so the aluminum flakes in the fluid look like long trails instead of small particles. This helps to visulaize how the fluid is moving: up through the center of the cell, then spreading out and sinking at the edges of the cell.

Images used with permission of *The Parabolic Press*. Van Dyke, M., 1982: *An Album of Fluid Motion*.

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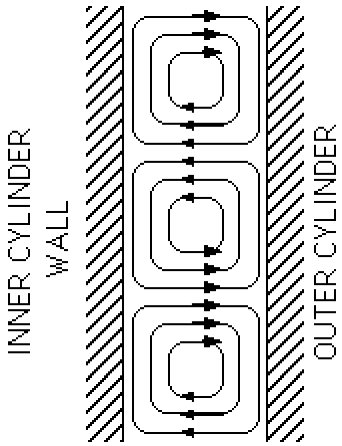
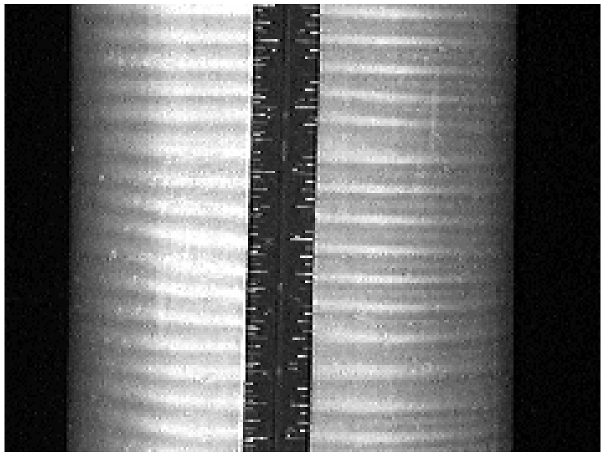
Convection cells can be seen on the surface of the Sun like the images that follow from http://quest.arc.nasa.gov/eclipse99/pages/SunActiv.html (left picture) and http://blackholesandastrostuff.blogspot.com/2007_09_01_archive.html (right picture)


2. Taylor-Couette Flow Instability

From http://www.princeton.edu/~gasdyn/Research/T-C_Research_Folder/Intro_to_T-C_Flows.html:

A cross sectional view of the flow field looks like the following (sketch on the left, image using the Kalliroscope flow visualization method on the right):





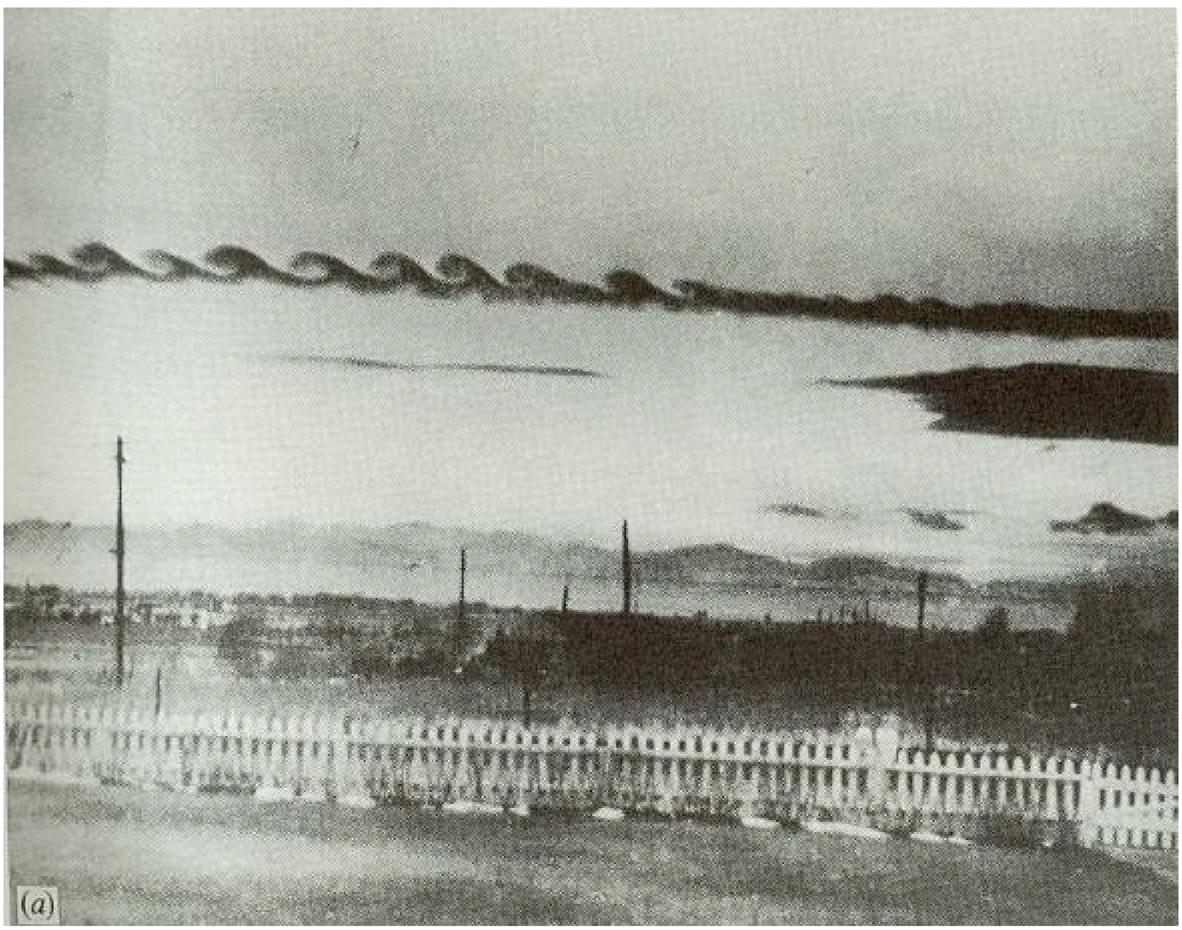
It is important to realize that while the first flow field was unstable at Taylor numbers of about 1708, this new flow field is stable at this point. The flow has reached a new, totally different, steady state. We reached this new state, just by slightly changing the rotation rate of the inner cylinder so that the Taylor number rose above 1708.

By further speeding up the inner cylinder (i.e. raising the Taylor number) other flow fields can be created. The final state is reached when the fluid between the cylinders is completely turbulent.

2. Kelvin-Helmholtz Instability

From http://www-frd.fsl.noaa.gov/mab/scatcat/ - Kelvin-Helmholtz breaking wave cloud over Laramie, Wyoming. Photo by Brooks Martner:

From http://www.math.waikato.ac.nz/~seano/research/turbulence-pictures.html:



Some shots of clouds showing the development of the **Kelvin-Helmholtz (KH) instability**. This instability can occur when two distinct layers of a fluid are in relative motion. For example, the top layer flowing faster than the bottom layer (from right to left in the above shots). The interface between the layers develops `wiggles' or rolls which can evolve into vortices. This instability in the interface means that the two layers start to mix, and can lead to fully developed turbulence in either layer.