Numerical Simulations of Rayleigh-Bénard Convection

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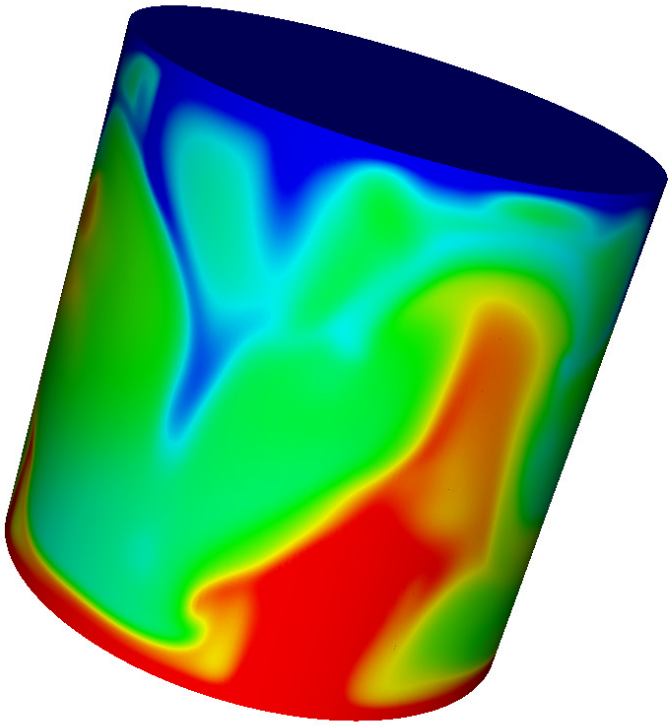
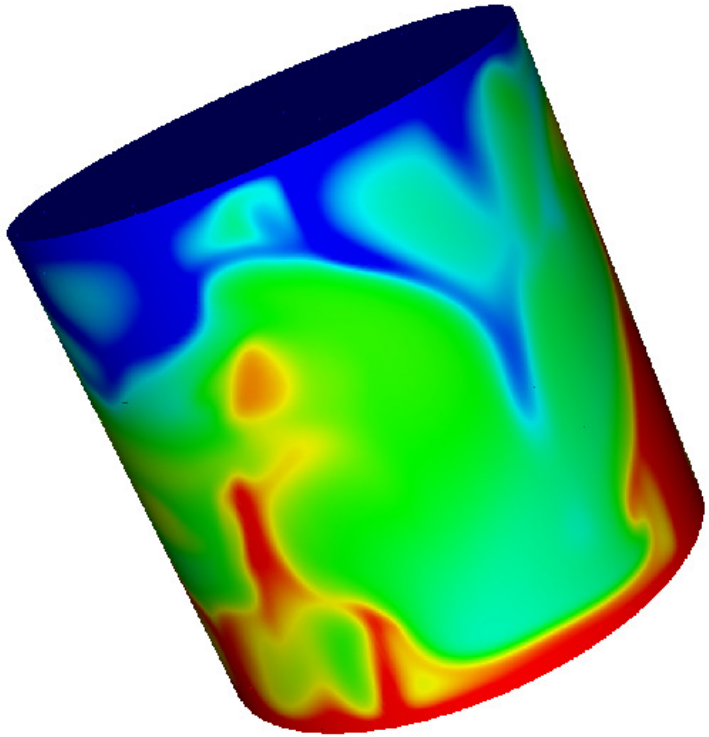
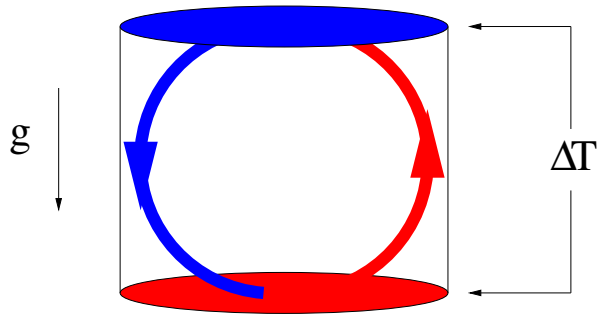
Nov. 11, 2021

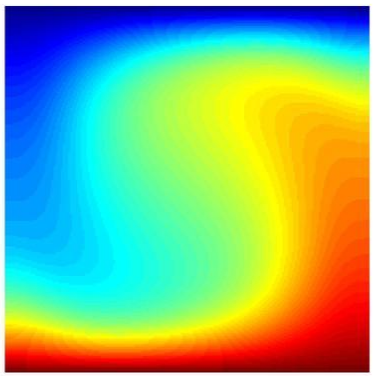


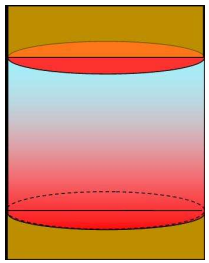


Rayleigh-Bénard Convection—steady-state

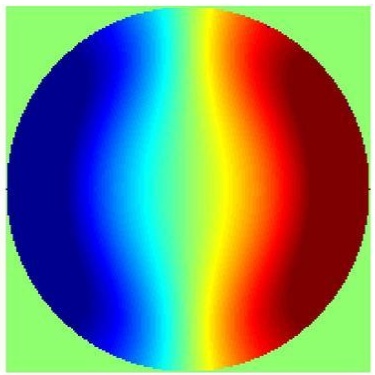
$$\Delta T = T_{\text{hot}} - T_{\text{cold}}$$

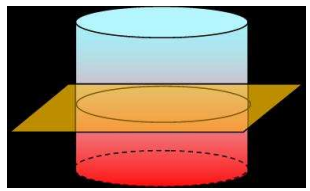






Vertical Slice

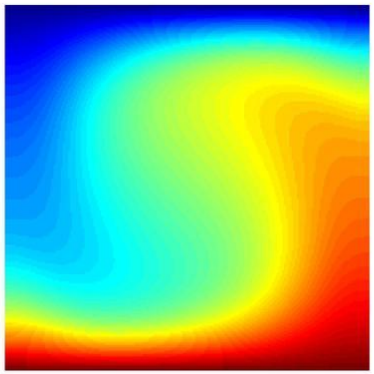




Horizontal Slice

Rayleigh-Bénard Convection—comparisons

Steady-State (Smaller ΔT)



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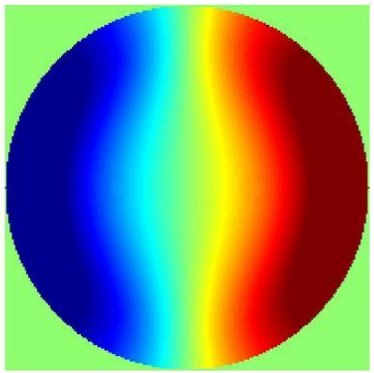
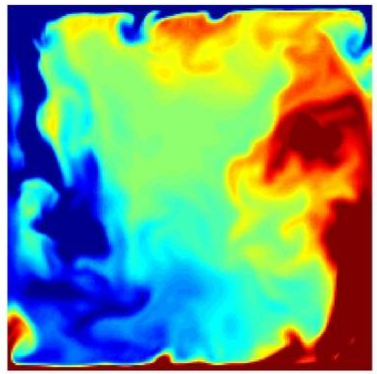


Horizontal Slice

Turbulence (Larger ΔT)



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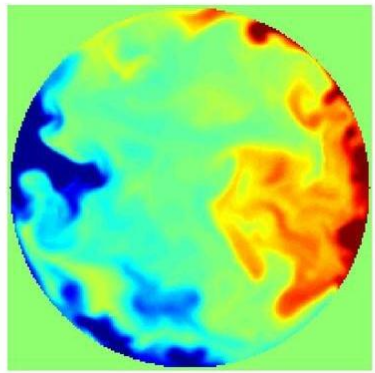
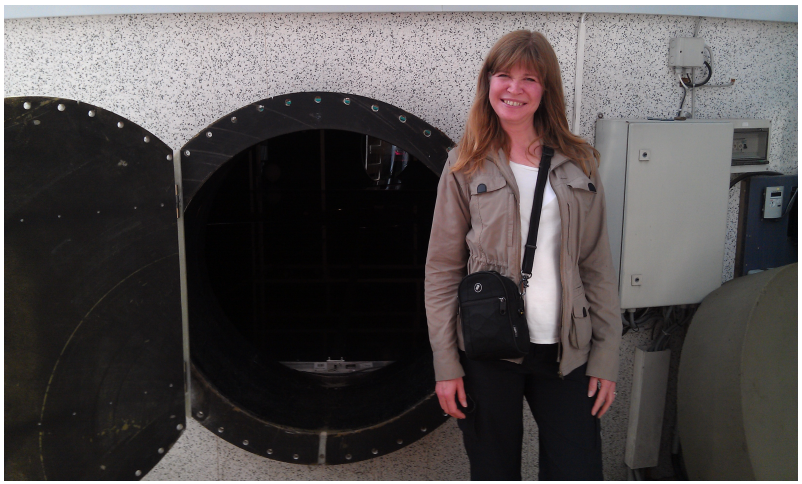
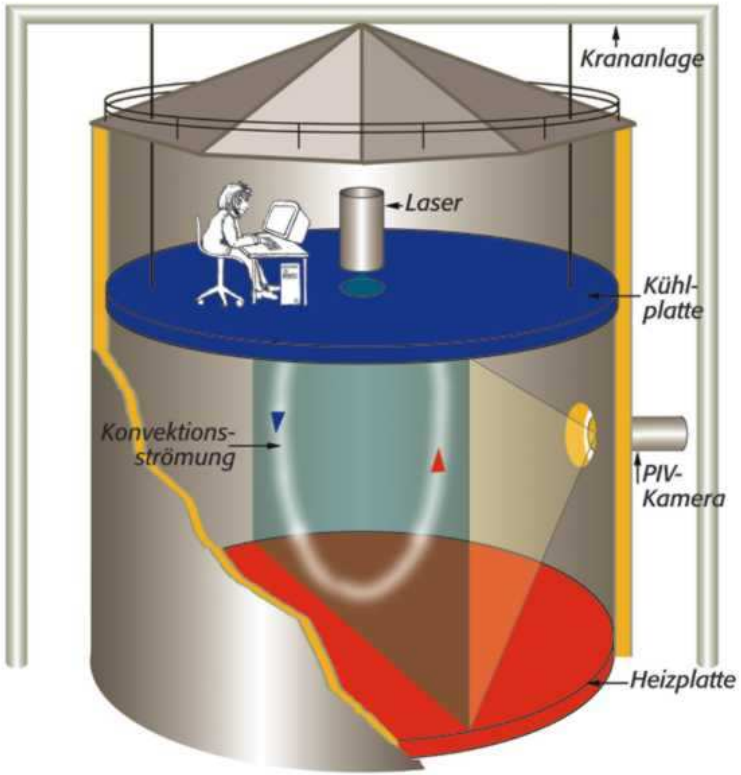


Horizontal Slice

How do people study Rayleigh-Bénard Convection?

Experiments—Barrel of Ilmenau

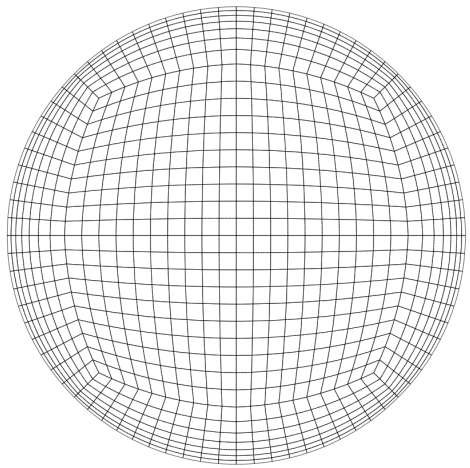




Numerical Simulations

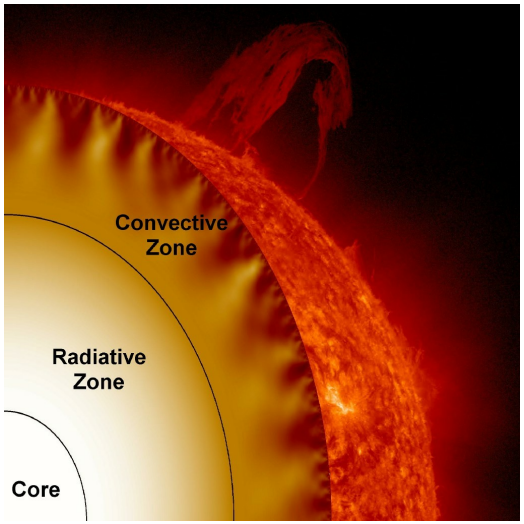
Numerically solves the equations which describe Rayleigh-Bénard Convection

- You can't solve these equations with pencil and paper
- We use a numerical code developed by Paul Fischer at Argonne National Laboratory to solve these equations
- Divide space into grid points, compute temperature, velocity and pressure of fluid at each data point, advance to the next time step, repeat...
- Example grid: 30720 elements
  11x11x11 points per element =
  40 million data points per time slice
  $\rightarrow$ parallelization is essential
  (current high = 17 million elements)



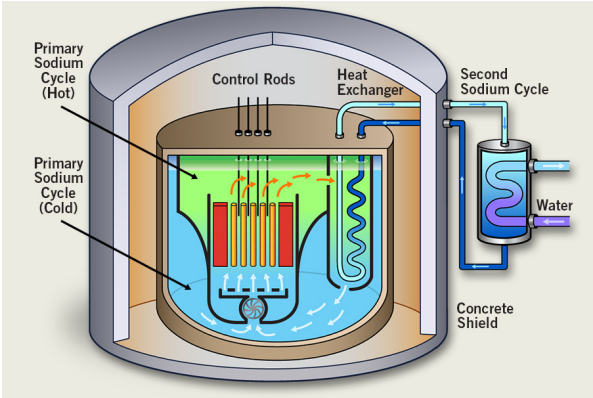
Why study Convection?

Solar Convection



solarscience.msfc.nasa.gov

Fast breeder reactors



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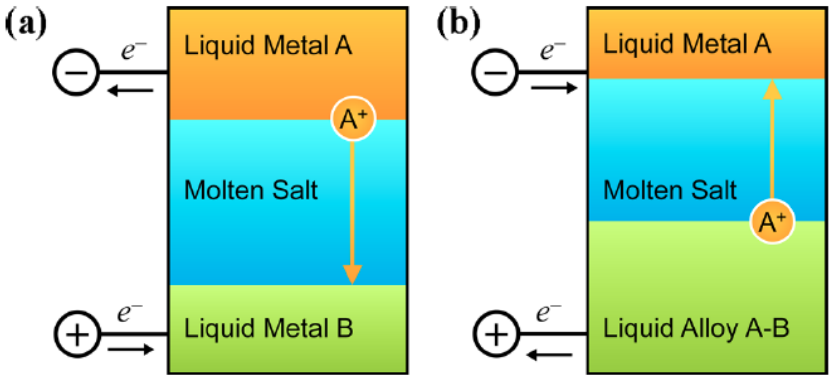
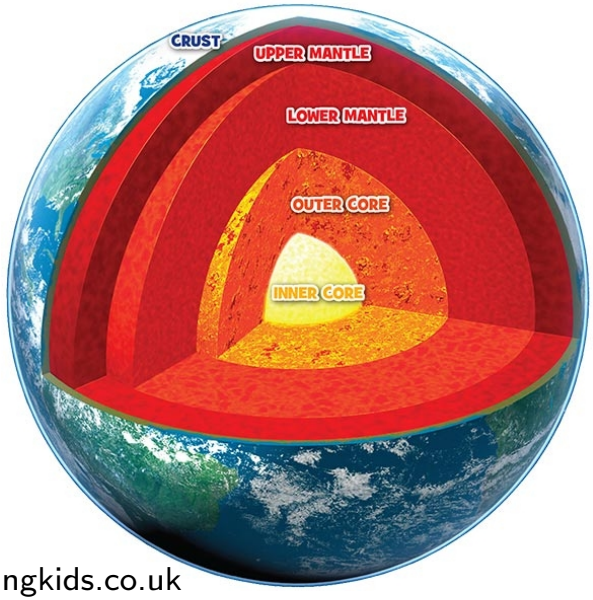
Liquid Metal Batteries



Kim, et.al., Chem. Rev. 2013

Earth's liquid metal core



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