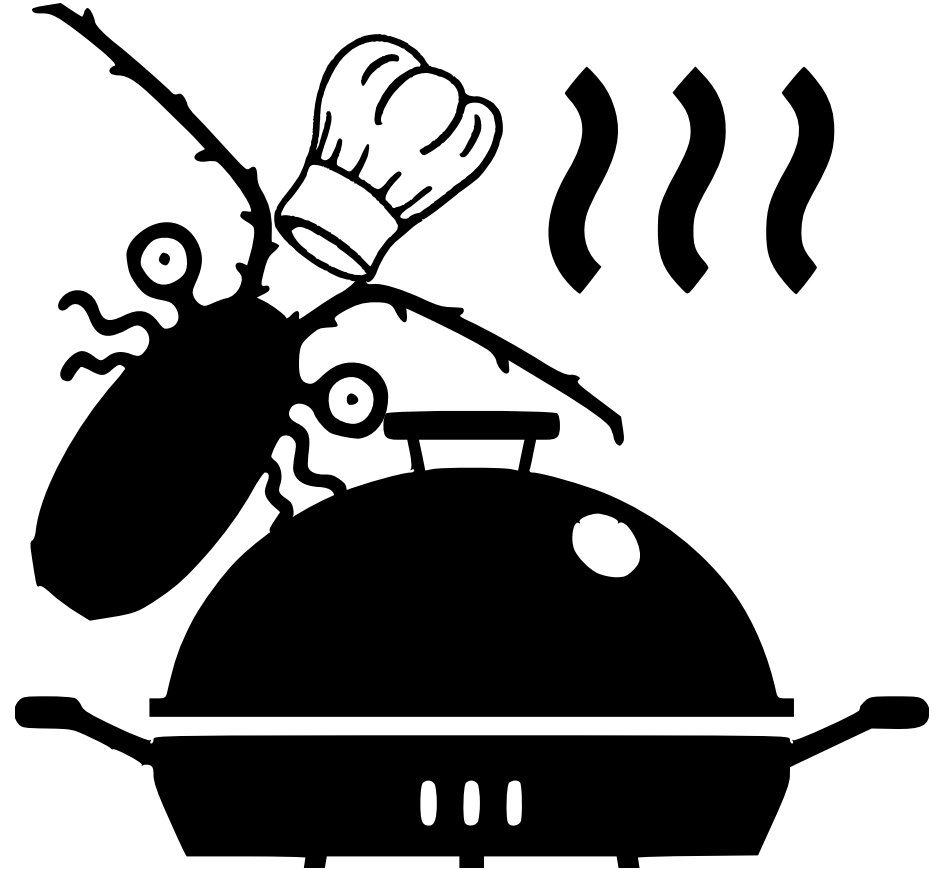


# Plankton Barbecue

Juan D. Chacon

Simon Fraser University Spring 2019



## Introduction

### Natural Thermal Convection

Those plumes coming out from our BBQ grill are caused by a difference in density consequence of temperature variations.

### Governing Equations

- ( $\approx$ ) **Momentum:**  
$$\frac{\partial \omega}{\partial t} + \frac{\partial \psi}{\partial y} \frac{\partial \omega}{\partial x} - \frac{\partial \psi}{\partial x} \frac{\partial \omega}{\partial y} = \frac{1}{Re} \nabla^2 \omega + \beta g \frac{\partial T}{\partial x}$$
- **Stream fnc - Vorticity - Velocity:**  
$$\nabla^2 \psi = -\omega, \quad u = \frac{\partial \psi}{\partial y}, \quad v = -\frac{\partial \psi}{\partial x}$$
- **Energy:**  
$$\frac{\partial T}{\partial t} + (\vec{u} \cdot \nabla T) = \frac{1}{RePr} \nabla^2 T$$
- **(Bonus!!!) Mass Transfer:**  
$$\frac{\partial c}{\partial t} + (\vec{u} \cdot \nabla c) = \frac{1}{Pe} \nabla^2 c$$

The last Eq. models a substance moving with the fluid.

## Method

To solve numerically the equations:

- 1 Set up the initial conditions for  $\psi$ ,  $u$  and  $v$ .
- 2 Solve the vorticity equation. (Exp FTCS).
- 3 Solve the Poisson equation for  $\psi$ . (Std. discr.  $\nabla^2$ ).
- 4 Compute the new velocity from  $\psi$ .
- 5 Solve the Energy equation for  $T$ . (Exp FTCS).
- 6 Solve the Mass transfer equation. (Exp FTCS).
- 7 Go to step 2.

## BBQ: Air Thermal Convection

As benchmark parameters we chose:

$$Re = 4365.30, \quad Pr = 0.72, \quad Pe = 0.07$$

For a rectangular Cavity width dimensions: 0.65m height, and 2.6m wide, and normalized temperatures  $T_c = -0.5$ ,  $T_h = 0.5$ . As shown in the figure the fluid shows some cell formations at long term.

## Cells and Spatial grid Dependence

1. Factorise  $x^2 - x - 12$ .

## And the plankton?

Pythoplackton sinks in the ocean (passive swimmers), the temperature in the ocean varies up to 10°C in a year, Is the convection what have this important individuals

## Glossary

verb	noun	meaning
add	addition	+
subtract	subtraction	-
multiply	multiplication	·
divide	division	÷
solve	solution	getting answer
substitute	substitution	$t = x^2$

Table 1: Word Formation

## Final Thoughts!

### Conclusions

- The number of cells depends on the geometry, aspect ratio, as well as the fluid parameters.
- The evidence of thermal cells depends on the size of the spatial discretization.
- (n.) factor  $\rightarrow$  two multiplied factors give result

### Pendings

- A solver using the projection method was considered, however, the staggered grid was an issue for the energy equation.
- An implementation using the second order FTBS scheme will help to deal with higher Reynolds numbers.
- The time convergence order might be improved using Crank Nicholson.

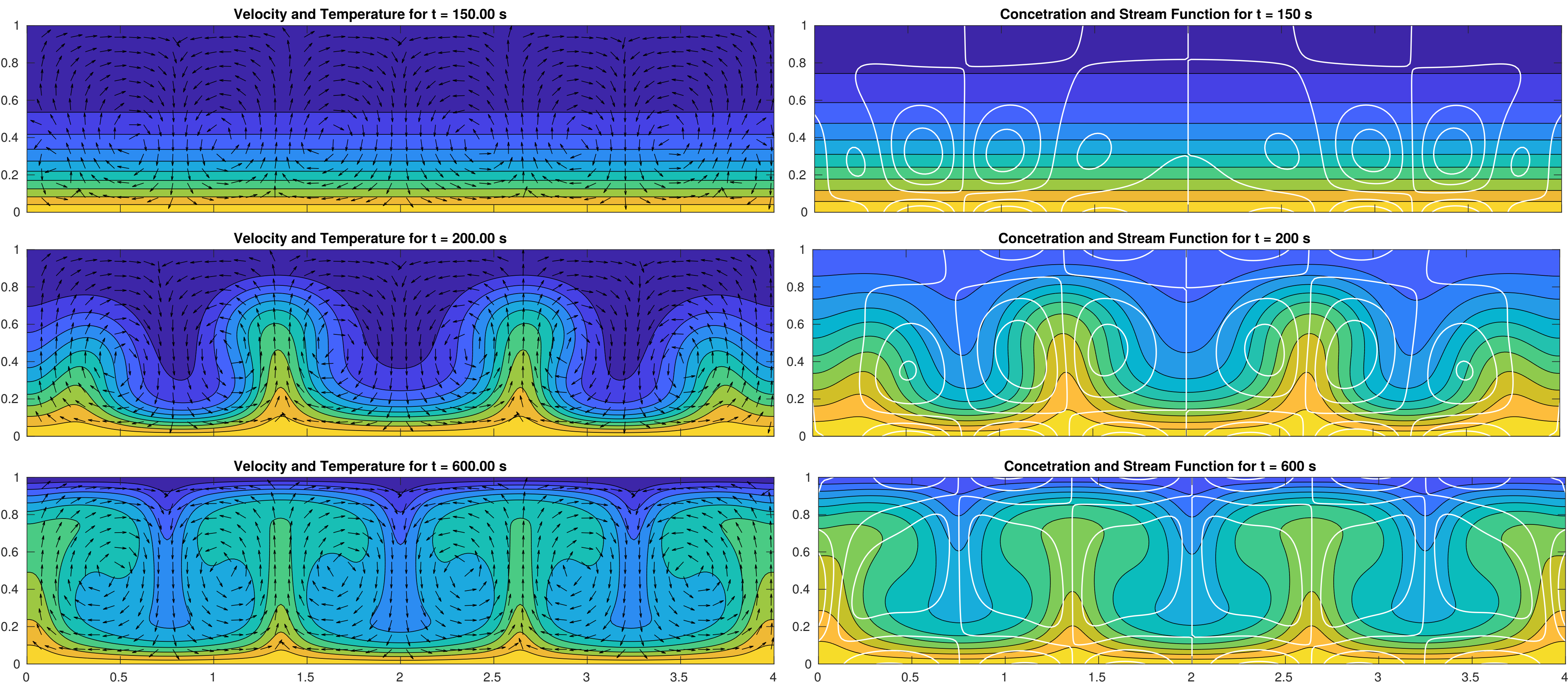


Figure 1: Cell behaviour

## Example of Factorisation

$$x = -7, \quad x = 3$$

## Proof of Vieta's Formulas

The same we could do with another pattern, which state that  $x_1 x_2 = \frac{c}{a}$ , but proving this is going to be your task in next section.

