

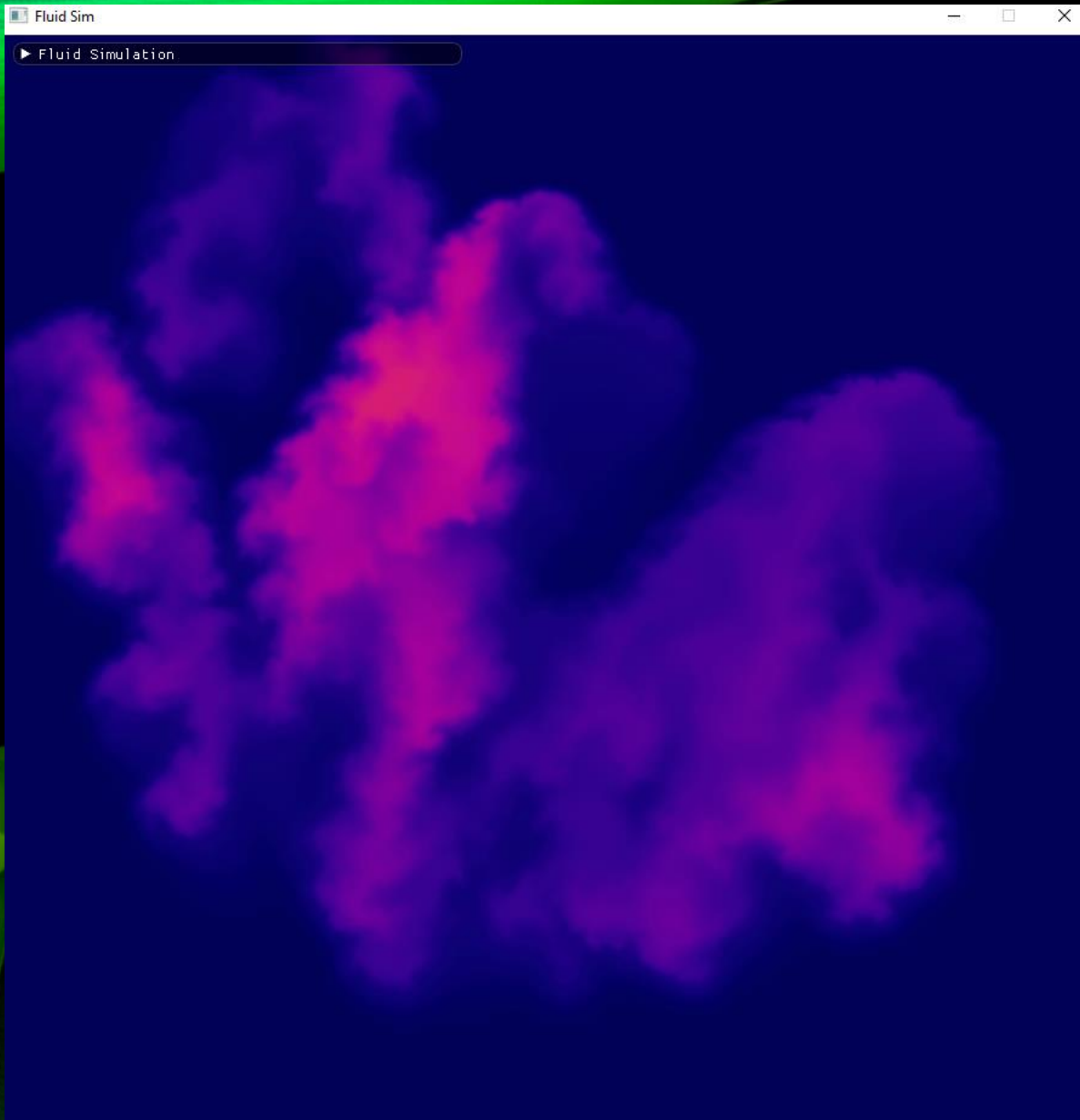


# FLUID SIMULATION SANDBOX

Game Physics 2019 Mini Project

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- Based on Stable Fluids solver by Jos Stam
- Semi-Lagrangian approach
- We simulate:
  - Density
  - Temperature
  - Velocity
- Allow users to play around with the fluid simulation in real time
- OpenMP for parallelism

# EXTERNAL FORCES

- Gravity based on *density*
- Buoyancy based on *fluid temperature* and *room temperature*

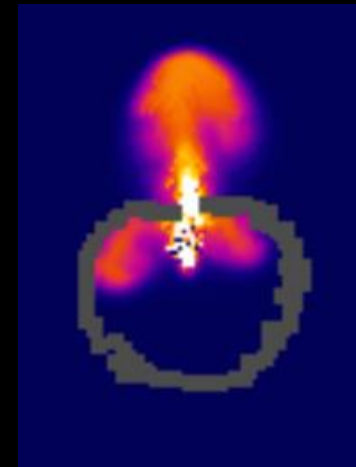
$$f_{ext} = \left( -kd + \sigma \left( \frac{1}{T_0} - \frac{1}{T} \right) \right) \hat{j}$$

- *Kappa* and *Sigma* are user parameters



# INTERNAL BOUNDARIES

- Original paper only supported edge *boudaries*
- We have added *internal boundaries*
- User can draw these



# VORTICITY CONFINEMENT

- Coarse grid
- Low amount of iterations in the *linear solver*
- *Numerical dissipation* causes high frequencies to dissolve
- Additional force computed from *curl*


$$\omega = \nabla \times \vec{v}$$

$$\eta = \nabla |\omega|$$

$$\psi = \frac{\eta}{|\eta|}$$

$$f = \varepsilon(\psi \times \omega)$$

- Force integrated using *Forward Euler*

The background features a black field with dynamic, flowing waves of green and orange. The green waves are prominent on the left side, while the orange waves flow from the top right towards the bottom right. The waves have a soft, ethereal quality with some internal texture visible.

DEMO TIME

# REFERENCES

- *Real-Time Fluid Dynamics for Games* - Jos Stam
- *Visual Simulation of Smoke* - Ronald Fedkiw
- *GPU Gems Chapter 38* - Mark J. Harris
- *GPU Gems 3 Chapter 30* - Keenan Crane