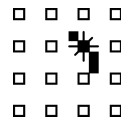


# VISUALIZATION OF VIRTUAL COMPLEX-FLUID RHEOMETRY IN A JUPYTER NOTEBOOK

**FORTISSIMO RHEOCUBE**

SURFsara, Electric Ant Lab



# WHO AM I?

Casper van Leeuwen

Computer Scientist

Visualization expert @ SURFsara

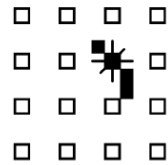
## EXPERTISE

- Scientific Visualization
- Web-based Visualization
- Virtual Reality
- Support users with the above



# ELECTRIC ANT LAB

Electric Ant Lab – Virtual Complex-Fluids Rheometry



## Electric Ant Lab

Scientific Modeling & Simulations  
on the rheometry of complex fluids

Complex fluids are everywhere:

Foodstuff



Care products



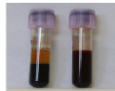
Paint/Coatings



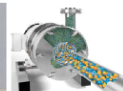
Smart Materials



Blood



Pharma/Ceramics



Their flow properties are key:

Production

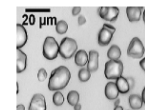
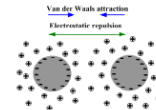


Application



Micro-scale structure & physics:

Particle shape and interactions



Micro-structure



Experiment has limited insight

Simulations can help BUT not everyone has the theoretical models and programming expertise, nor the computing resources to run them.

**We do!**

Slide courtesy: Electric Ant Lab

# ELECTRIC ANT LAB

## Electric Ant Lab – Virtual Complex-Fluids Rheometry

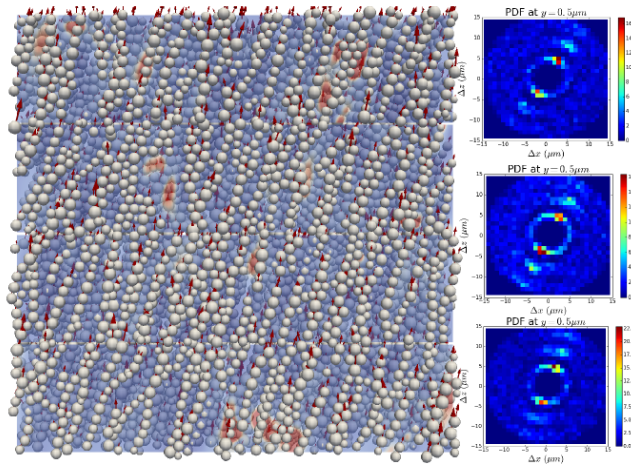
### What we offer:

#### Contract Research:

- Complex-Fluids Rheology & Microstructure
- High-Fidelity Modeling & Simulations
- Virtual Material & Microfluidics Prototyping

#### Simulations as a Service:

Do simulations by your self, without knowing anything about programming or supercomputers



**RheoCube**  
Virtual Complex-Fluids Rheometry

Setup simulations like setting up experiments in the lab



**Want to do your own simulations for your specific system? We are looking to expand RheoCube!  
Come see us for more information!**

Slide courtesy: Electric Ant Lab

# RHEOCUBE

## THE VIRTUAL COMPLEX FLUID RHEOMETER



# SIMULATION PIPELINE

RheoCube

Logout

Particles

Demo Particle

Allows you to select particles prop...

BASF CIP standard

BASF CIP particles magnetism and...

BASF CIP particles\_Standard

BASF CIP particles magnetism and...

Fluids

Demo Fluid

Allows you to select fluid properties

AeroShell41 standard

Aeroshell Oil as used by Ioniqa

AeroShell41\_Standard

Aeroshell Oil as used by Ioniqa

Materials

Demo Material

Mix your particles with your fluid t...

MRF20 standard

A 20 volume percent dispersion of...

MRF20

A 20 volume percent dispersion of...

Samples

Demo Sample

Create a sample

MRF20 standard

small sample

MRF20-2

MRF20-BS64

Smaller box size for initial check

MRF20-BS96

Same settings as my first attempt ...

States

Demo State

small-sample state

MRF20 standard

small-sample state

MRF20-1-S1

MRF20-BS64-S1

State 1 of the MRF

Experiments

Demo Experiment

design your experiment

MRF20 H127k x 1000/s

One fixed shear rate (1000 1/s) H...

MRF20 H127k y 1000/s

One fixed shear rate (1000 1/s)

MRF20 H127k 1/s

One fixed shear rate (1/s)

MRF20 H64k 1000/s

One fixed shear rate (1000 1/s)

MRF20 H32k 1000/s

One fixed shear rate (1000 1/s)

MRF20 H0 1000/s

One fixed shear rate (1000 1/s)

Postprocessing

Postprocessing

Postprocessing session

# GOAL

Visualizations in a fluid suspension simulation post-processing pipeline



## REQUIREMENTS

- Jupyter-notebook integration
- Run interactively on your own device
- Connected to SuSiPoP;  
A python module for **SU**sension **SI**mulation **PO**st  
**P**rocessing

## DATA MODEL

Particle data:

- Particles consists of spheres
- Variable sizes
- Multiple data fields (velocity, forces, shear stresses, etc.)

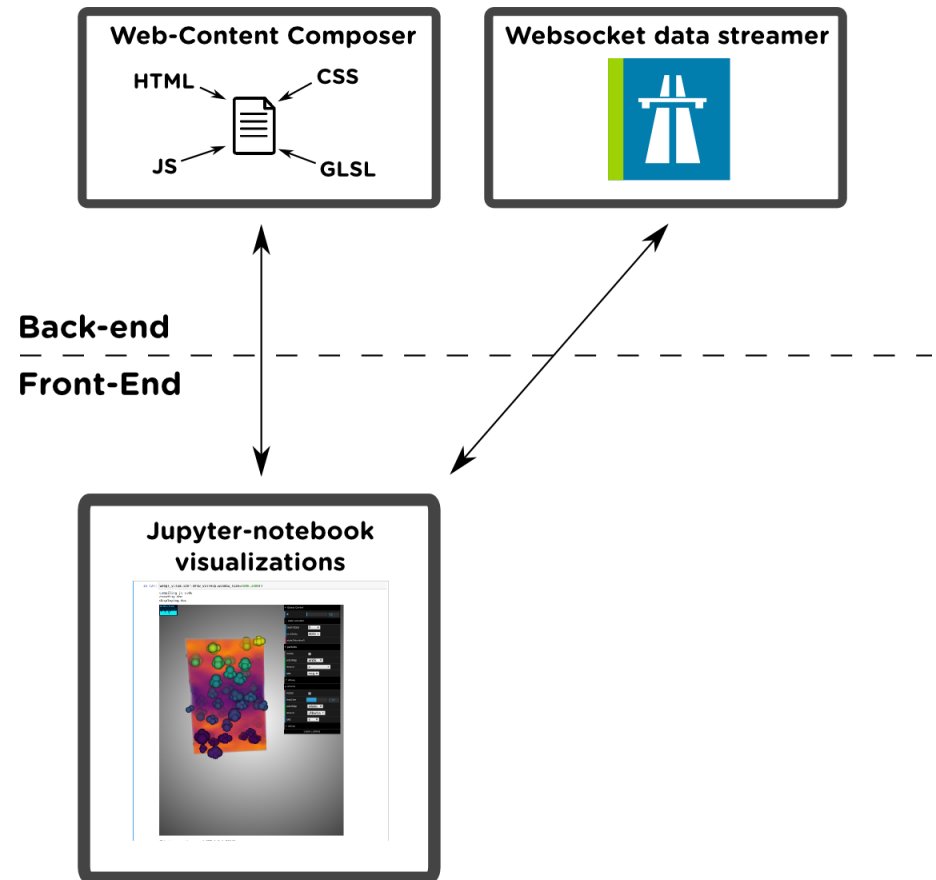
Fluid data:

- Volumetric data
- Multiple data fields (flow velocity, forces, shear stresses, etc.)

# HOW?

## JUPYTER-NOTEBOOK INTEGRATION

Web-Content Composer  
Jupyter WebGL integration  
Autobahn data-handler



## **CHALLENGE: SPHERICAL PARTICLES IN WEBGL**

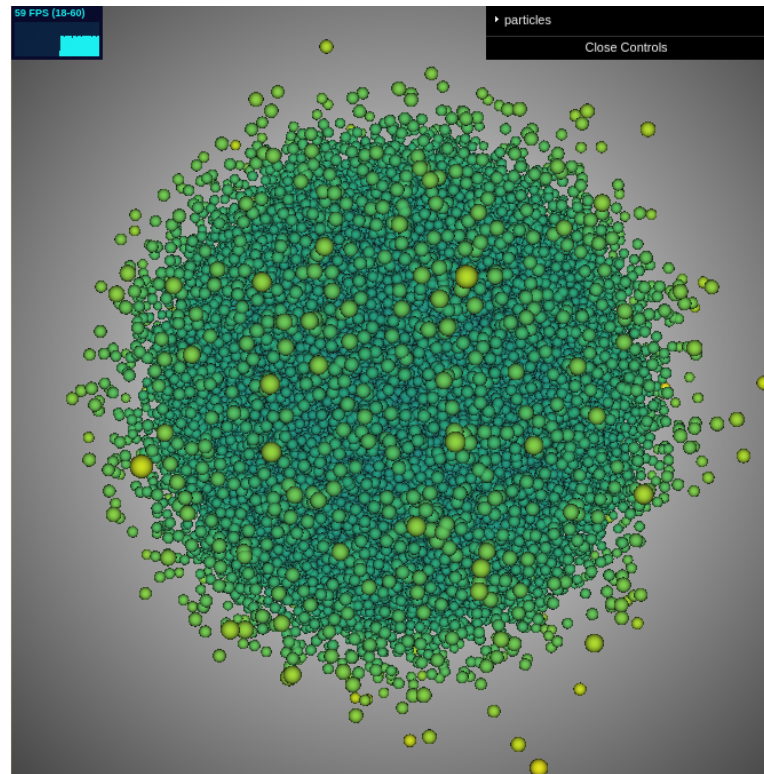
Spherical geometry in general can get *demanding* on graphic resources (~200+ triangles)

## **SOLUTION: IMPOSTOR PARTICLES IN WEBGL**

*Point primitives* shaded as spheres instead of a spherical geometry:

- Big performance gain
- Large numbers of particles

# PARTICLE VISUALIZATION IN WEBGL



# VOLUME VISUALIZATION IN WEBGL

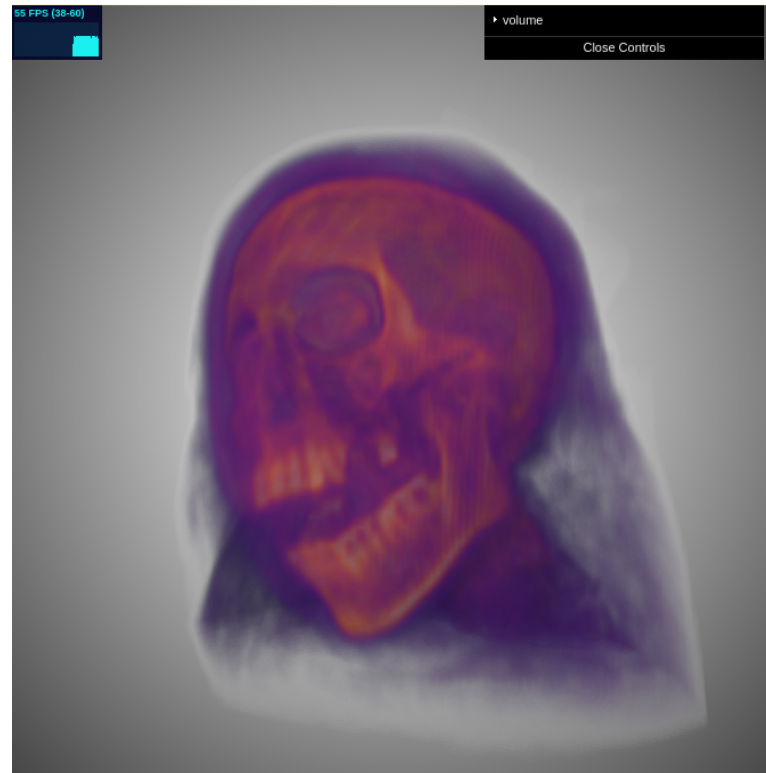
## Challenges:

- Performance
- WebGL 1.0 → No 3D textures

## Solutions:

- Shader-based volume rendering
- Volume slice tiling on 2D texture

# VOLUME VISUALIZATION IN WEBGL





# FUTURE WORK

- Other visualizations of the data:
  - Slice view
  - A better vector representation
  - Different shaped particles
- Better control over the visualization parameters
- WebGL 2.0

# DEMO TIME!

Rheocube Jupyter Notebook