
Analysis of Rayleigh-Taylor Instability: Bubble and Spike Count

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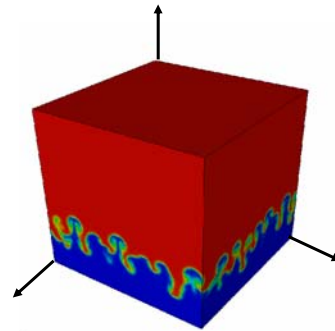
UCRL-PRES-225094
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by University of California Lawrence Livermore National Laboratory under
contract No. W-7405-Eng-48.

<http://www.llnl.gov/casc/sapphire>



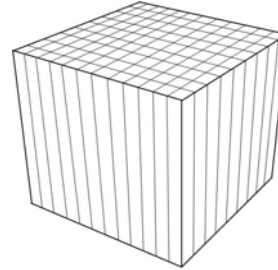
Goal: use image analysis to characterize and track bubbles and spikes

- Two high-fidelity simulations of the Rayleigh-Taylor instability
 - Atwood number: 0.5
- Goals of the analysis
 - **bubble counts**
 - bubble sizes
 - distances between bubbles
 - bubble dynamics



The data is obtained from the Miranda code on a 3-D regular Cartesian grid

- LES simulation*
 - 1152**3 grid points
 - 7 variables per grid point
 - 759 time steps
 - **30TB analysis data**
- DNS simulation**
 - 3072**3 grid points
 - 5 variables per grid point
 - 248 time steps
 - **80TB analysis data**



* Cook, Cabot, and Miller, *Journal of Fluid Mechanics*, 511, 2004.

** Cabot and Cook, *Nature Physics*, 2, 2006.

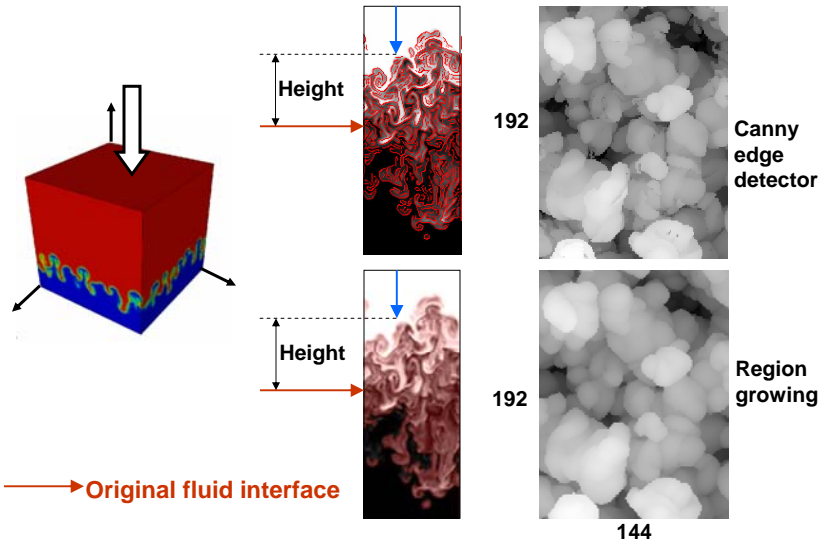
Sapphire/AG 3

There are several challenges to the analysis

- Lack of a precise definition of a bubble
 - range of scales of the structures of interest
- Massive size of the data
 - distributed nature of output at each time step
- Requirements of the analysis algorithms
 - low computational cost
 - applicable to distributed data
 - few parameters
 - relatively insensitive to choice of parameters
 - a single algorithm and parameters for all time steps
 - multiple algorithms for verification

Sapphire/AG 4

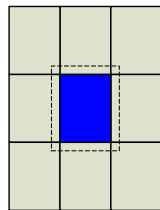
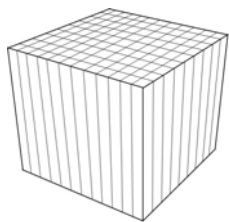
We use the bubble height to generate a 2-D image: the height-depth map (HDM)



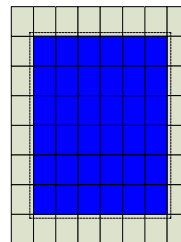
Sapphire/AG 5

We had several options to parallelize the HDM calculation for the full cube

- Process all columns at once
- Process a column at a time and combine results
- Combine a few columns, process them, and then combine the results



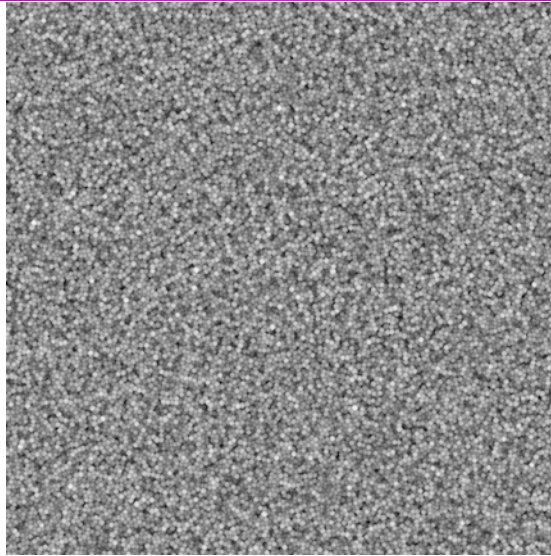
8 extra reads/column
34.5K seconds/dump
(LES)



~0.78 extra reads/column
17.5K seconds/dump
(LES)

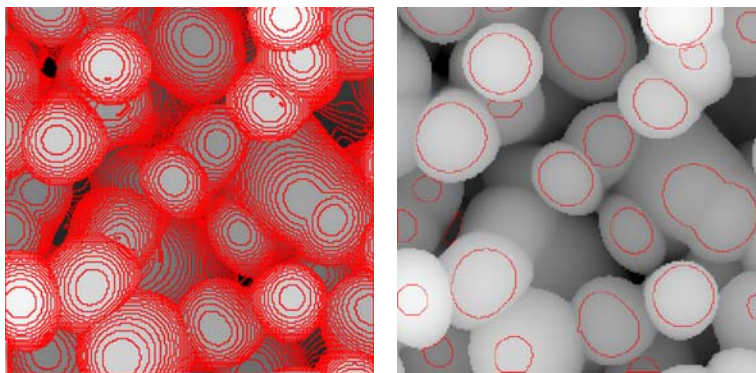
Sapphire/AG 6

Movie: Bubble height map for the LES data



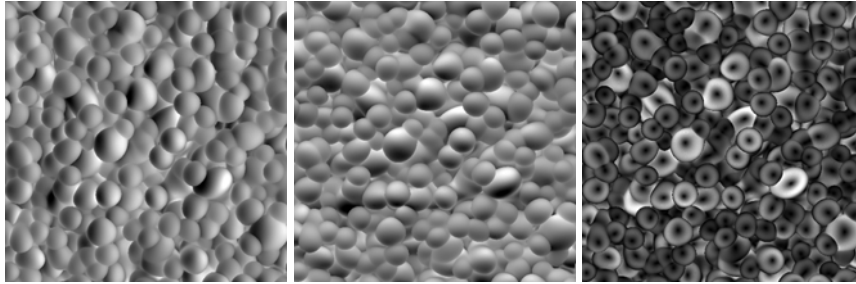
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Bubble counting – Method 1: 2D region growing (DNS, time step 50)



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Bubble counting – Method 2: the mag- X-Y velocity (DNS, time step 50)



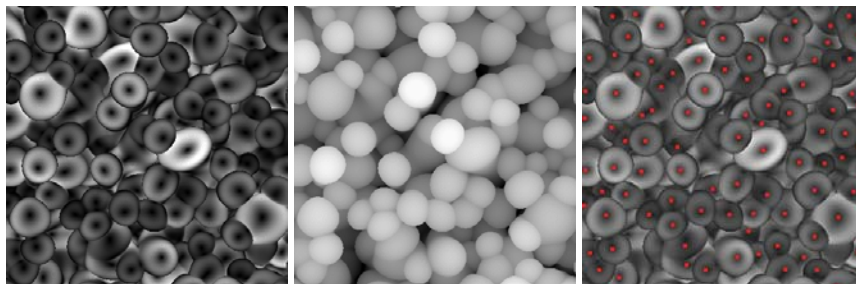
X velocity

Y velocity

Mag X-Y velocity

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Bubble counting – Method 2: identifying the bubble tips



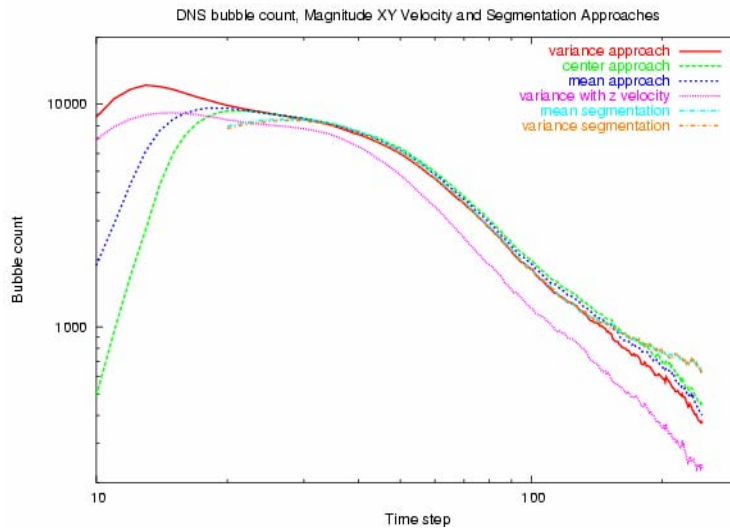
Mag X-Y velocity

Height-depth map

Bubble tips

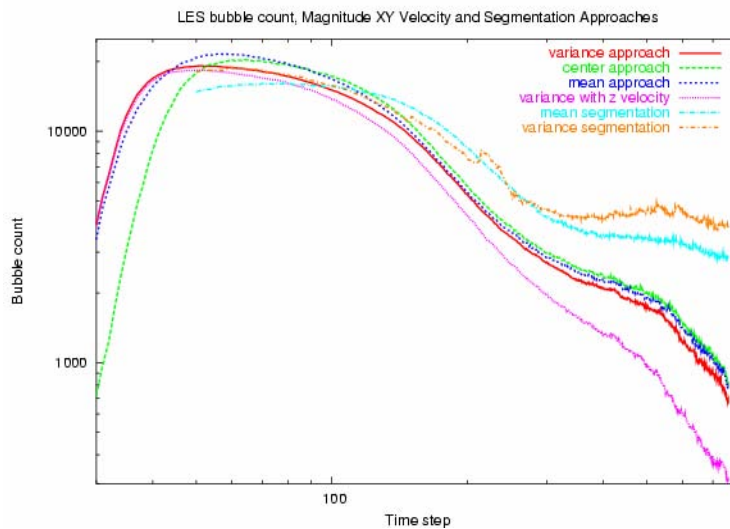
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Bubble counts over time: DNS data



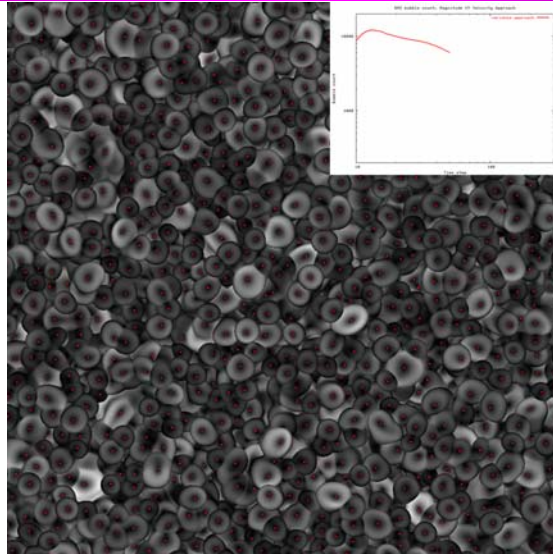
Sapphire/AG 11

Bubble counts over time: LES data



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Movie: Bubble tips for DNS data (1Kx1K subset of full image)



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Acknowledgements

- William Cabot and Andrew Cook for providing the data
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Technical report available at: www.llnl.gov/casc/sapphire

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