

Micro-scale two-phase flow dynamics

Lecture 1 Introduction

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Outline

- Multi-scale physics
- Multiphase flow
- Micro-scale flow and heat/mass transfer

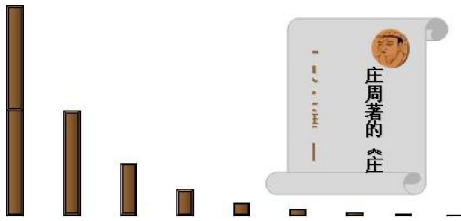


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From Macro-scale to Micro-scale



- “一尺之捶，日取其半，万世不竭” 《庄子·天下》
- An ancient Chinese philosopher said: suppose you take a meter-long wood stick and cutoff half of it each day; you will never reach an end even after thousands of years!




$$\frac{1/3}{2^{n-1}} = \frac{1/3}{2^{31-1}} = 3.1 \times 10^{-10} = 0.31nm$$



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Multi-scale physics

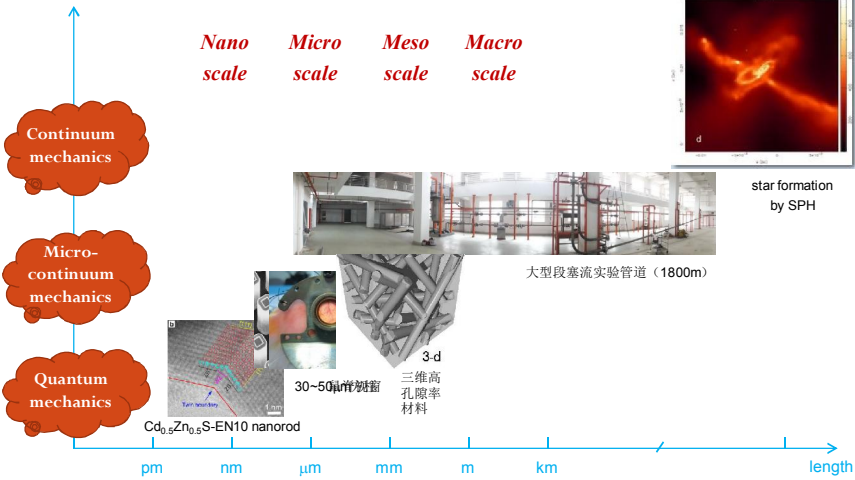


*Nano
scale*

*Micro
scale*

*Meso
scale*

*Macro
scale*



pm
nm
μm
mm
m
km
length

Quantum mechanics

Micro-continuum mechanics

Continuum mechanics

Cd_{0.2}Zn_{0.8}S-EN10 nanorod

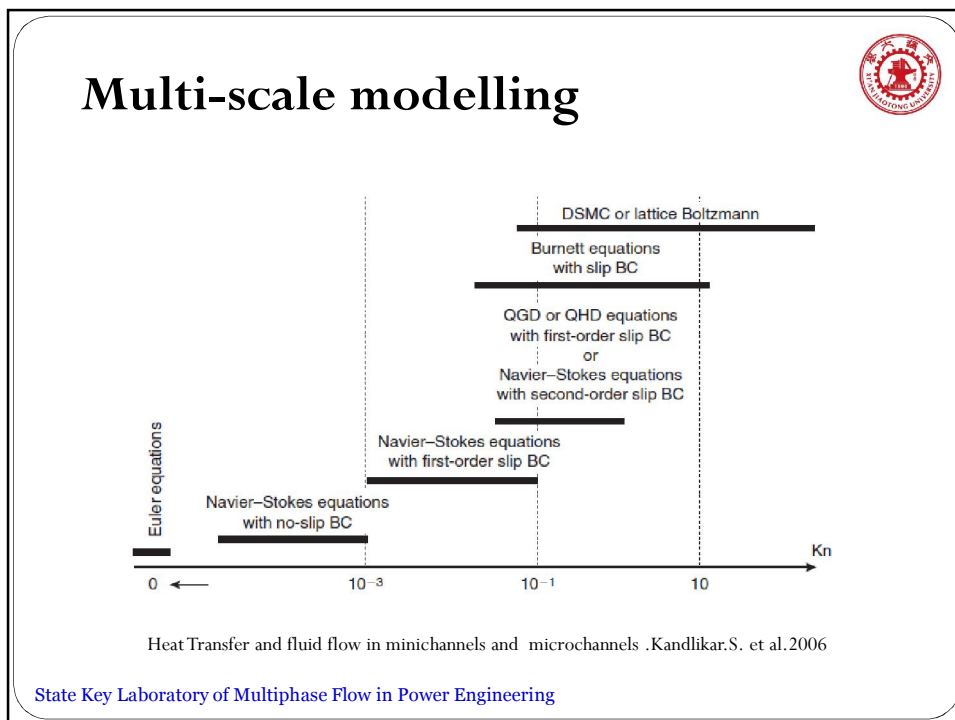
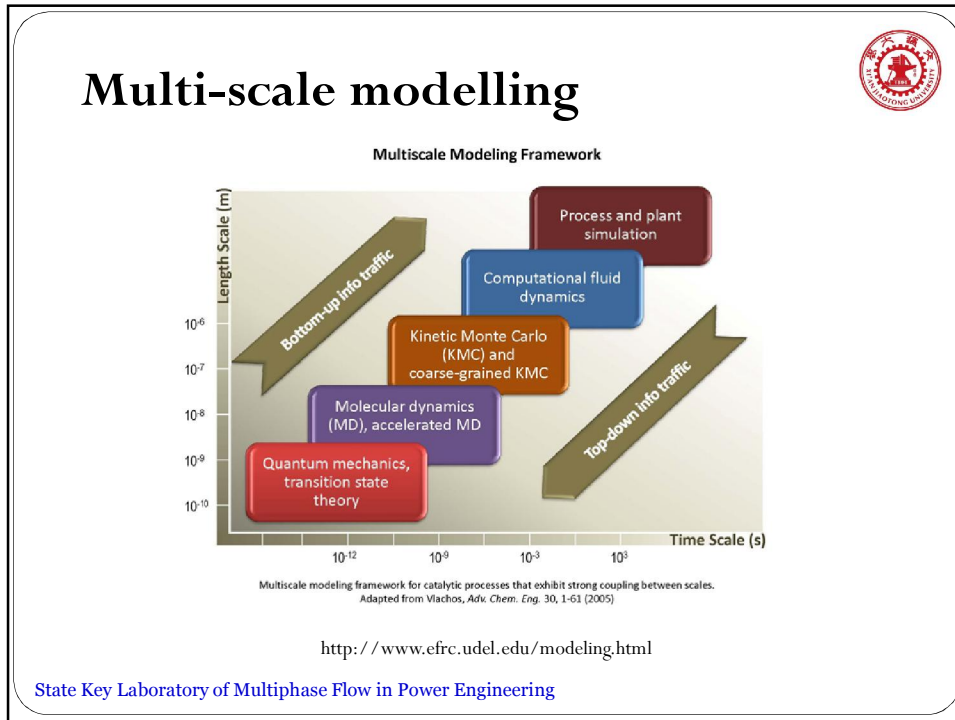
30-50nm 纳米材料

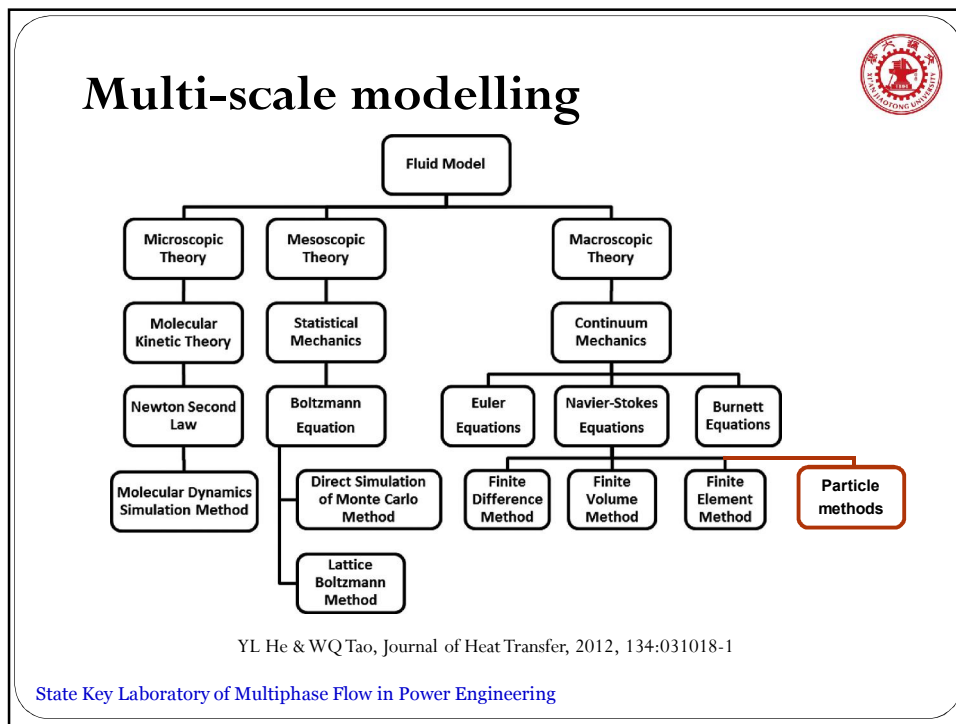
3-d 三维高孔隙率材料

star formation by SPH

大型段塞流实验管道 (1800m)

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- ## Outline
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 - **Multiphase flow**
 - Micro-scale flow and heat/ mass transfer
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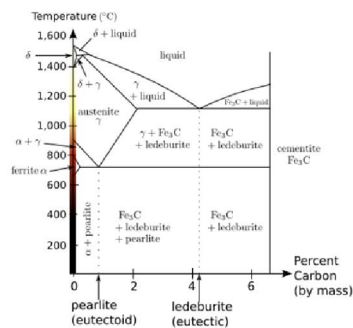
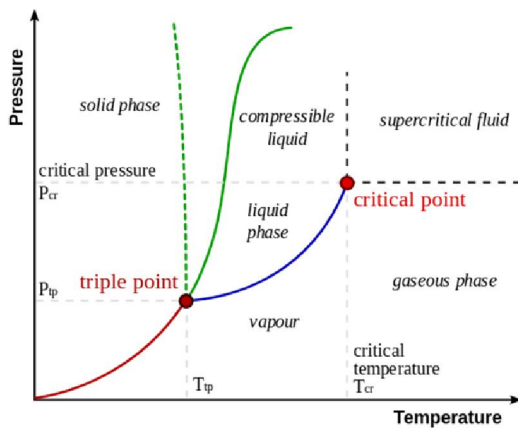
Multiphase flow

- A phase is a region of space (a thermodynamic system), throughout which all physical properties of a material are essentially uniform.
- A simple description is that a phase is a region of material that is **chemically uniform, physically distinct**, and (often) **mechanically separable**. (wikipedia)
- Each of the phases is considered to have a separately defined volume fraction (the sum of which is unity) and velocity field with distinct **interface, either deformable or not**.

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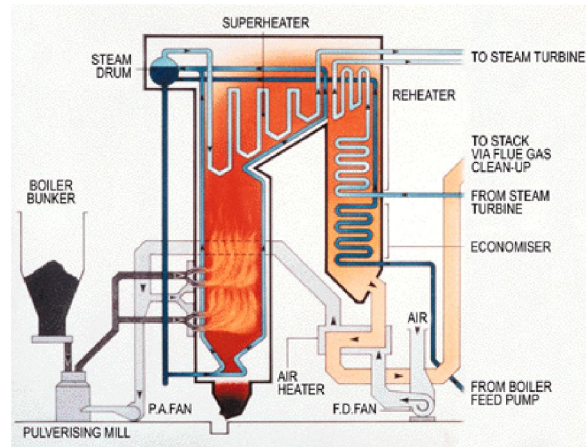
Multiphase flow



[http://en.wikipedia.org/wiki/Phase_\(matter\)](http://en.wikipedia.org/wiki/Phase_(matter))

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Two-phase flow



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Gas-liquid two-phase flow

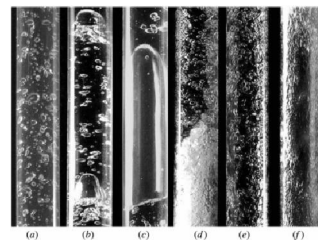




**Two-Phase Gas-Liquid Flow
Visualization Test Clip**

Inclination : -90 deg
ReSL : 11500

July 27, 2010
Swanand Bhagwat



E S Rosa et al 2012 Meas. Sci. Technol. 23 055304

<http://ghajar.ceat.okstate.edu/>

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Gas-liquid two-phase flow



<http://us.clipdealer.com/video/media/692255>



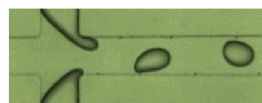
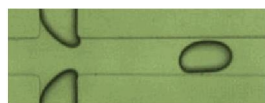
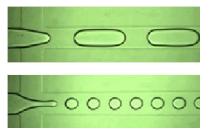
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Liquid-liquid two-phase flow



俄罗斯石油泄漏

<http://www.epchina.com/2011/1222/28640.shtml>



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Gas-solid two-phase flow



Fluidized bed
Osaka University



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Solid-Liquid two-phase flow



Zalman launches world's first CPU liquid cooler using nanofluids



Coal slurry
<http://www.citizenscoalcouncil.org>



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Multiphase flow



Oil-water-gas-sand



沙尘暴与雷雨齐袭新疆博湖

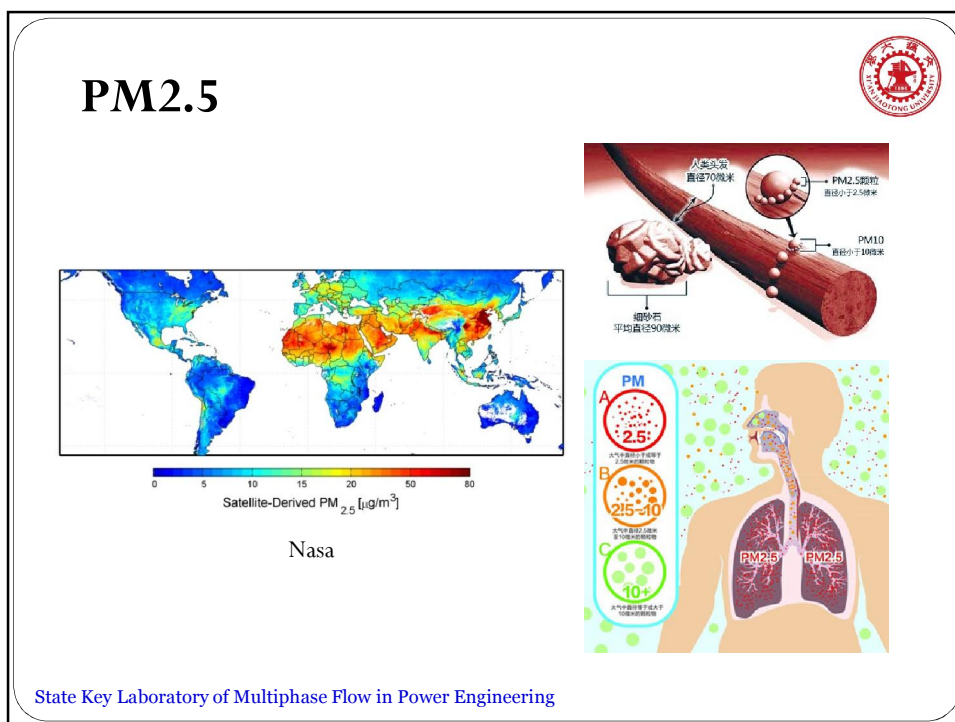
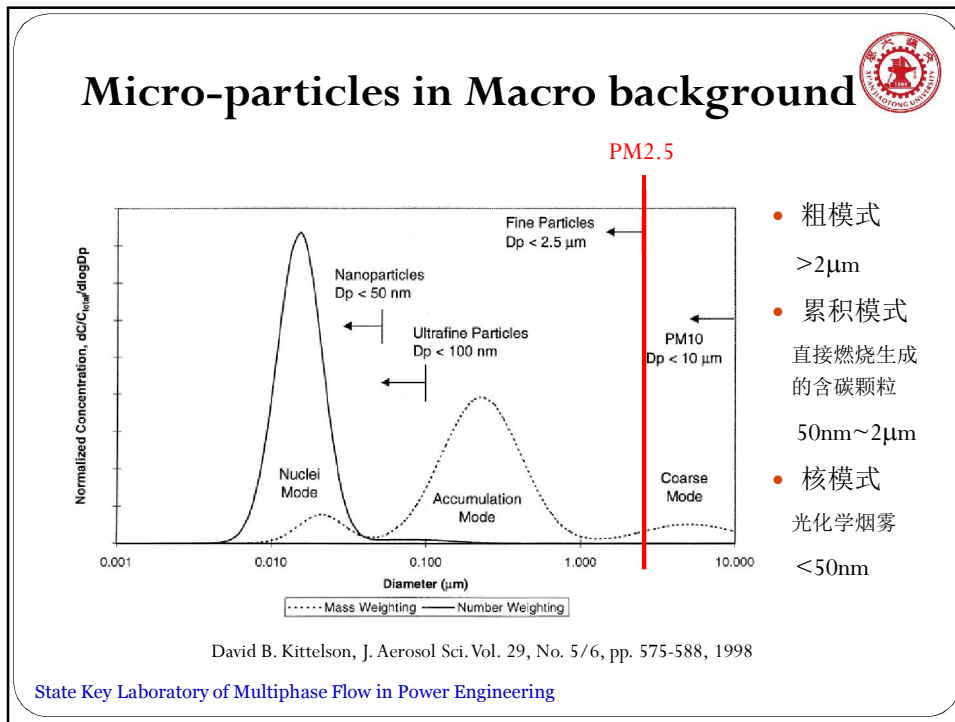
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PM2.5



2013.12.23




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Micro time-scale


- **Vascular dermatosis**




Port Wine Stain, PWS




Hemangiomas
- **Pigmentary dermatosis**




Ota's nevus




nevus cell nevi



melanoma



coffee speckle



age pigment

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Micro time-scale

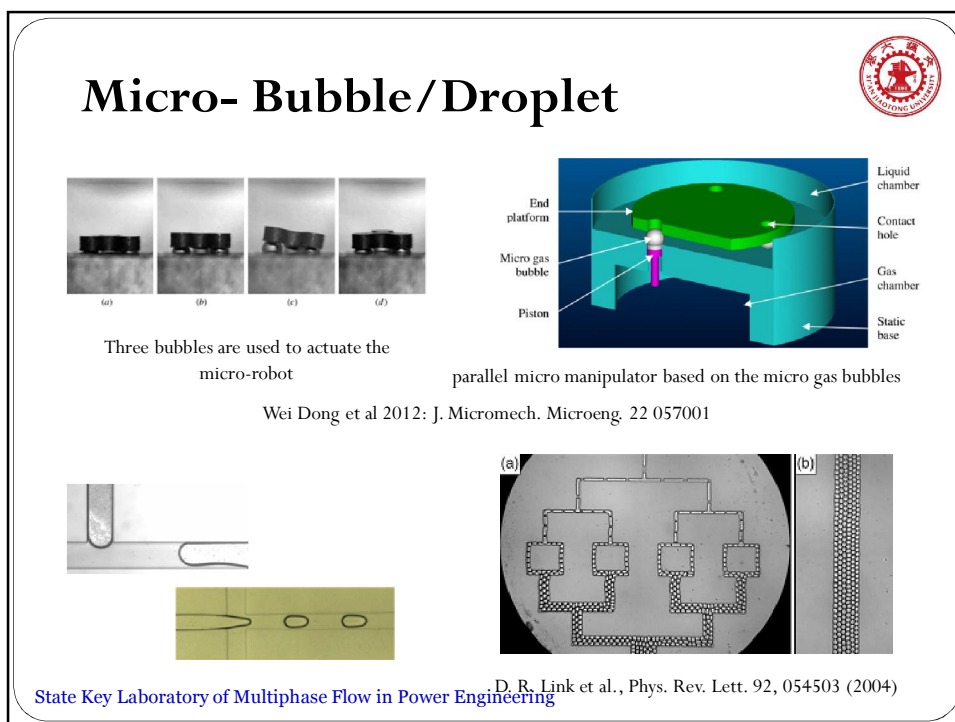
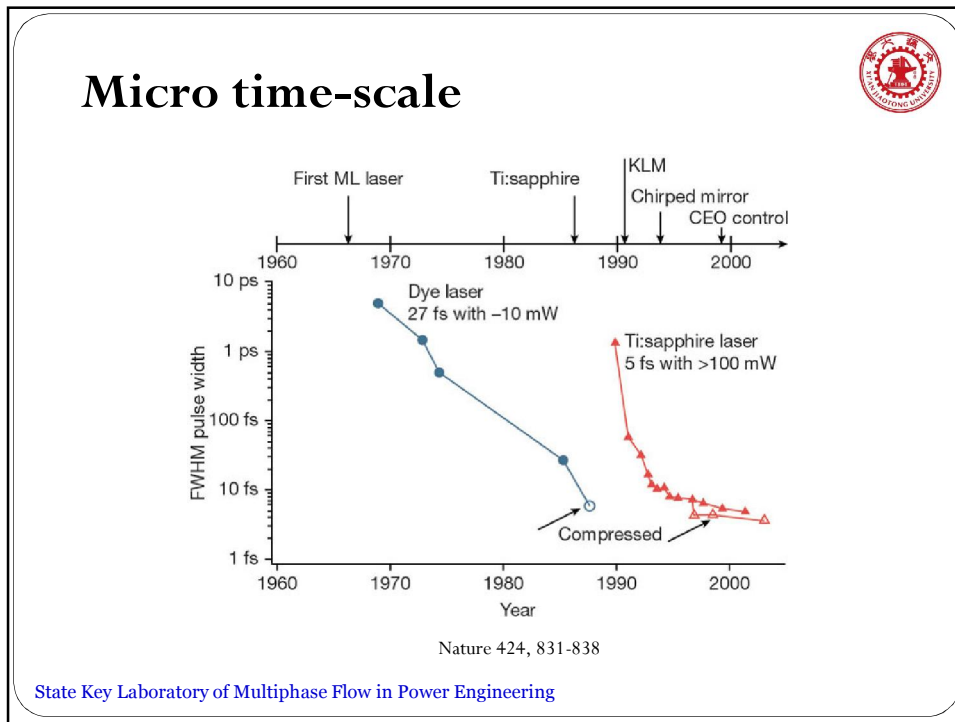
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Micro time-scale

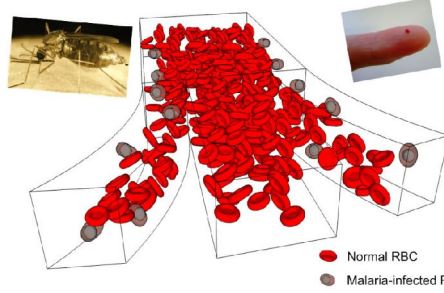
1064nm激光照射下的光热凝块生成和逆流现象
0.3ms, 57J, 3HZ, 3脉冲

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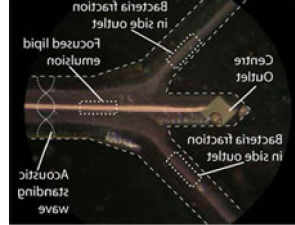




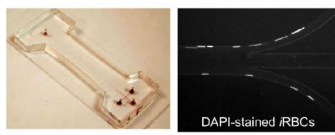
Micro- Particle/Cell



● Normal RBC
● Malaria-infected RBC

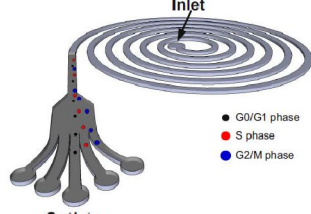


http://www.elmat.lth.se/forskning/nanobiotechnology_and_labonac hip/research/rapid_bacteria_separation_in_food_stuff/



DAPI-stained RBCs

Lab on a Chip, vol. 10, 2605 (2010)




● G0/G1 phase
● S phase
● G2/M phase

Inlet

Outlets

<http://web.mit.edu/smart/research/biosym/BioSym-Sub-projects-Thrust%202.html>

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Exercise 01

- Please give the description of micro-scale flow/heat transfer related your research.

To be continued.....

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