21.Particles 3

Wednesday, November 14, 2018 2:26 PM

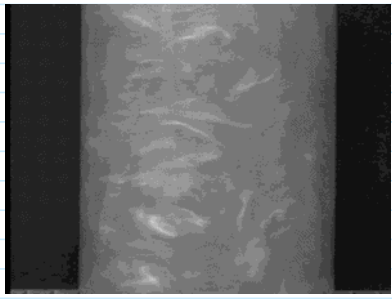
Last time: Particle generation in air: Smoke and Fog
Today:
Particle gen in water

Particles for Water

Rheoscopic fluids:

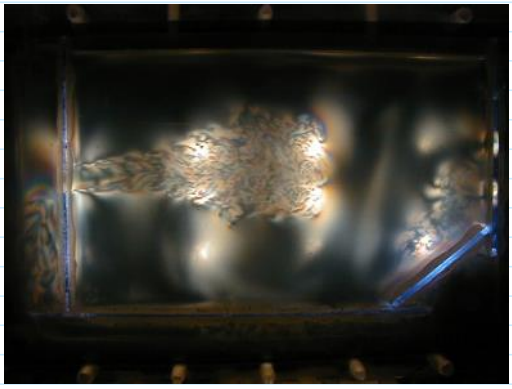
Pearl Ex (art pigment, TiO_2 coated mica).

'Pearl Swirl' $5/gallon from Steve Spangler Science
Shiny opaque or translucent particles, crystal flakes, ~10 µm size, aligns with shear gradient.
Used in soaps, shampoos
https://www.youtube.com/watch?v=vrTM9O6owII
Probably the same as:
Stearic acid crystals extracted from shaving cream,
Borrero-Echeverry, Daniel, Christopher J. Crowley, and Tyler P. Riddick. "Rheoscopic Fluids in a Post-Kalliroscope World." *Physics of Fluids* 30, no. 8 (August 1, 2018): 087103. https://doi.org/10.1063/1.5045053.



Check out the Taylor Couette Instability demo in the ITLL Lobby. Tall blue column.

'Blackstock' fluid, now 'KaleidoFlow Rheoscopic Fluid'



Streaming birefringence, seen when viewed between polarizing filters
Has 2 indices of refraction
Suspension of microscale mica flakes.

http://www.laminarsciences.com/

http://buphy.bu.edu/~duffy/thermo/4B20_77.html

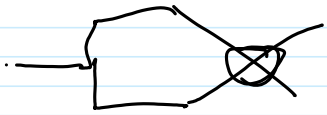
For individual particle images (PIV)

Neutral buoyancy

- Corn starch (diluted)
- Glass or polystyrene microspheres
- Latex bubbles
- Rust (filtered)
- Alumina
- Wax beads (Pine Sol)

Here F2018

Mica powder for makeup
polishing powder
ultrasound to break up clumps



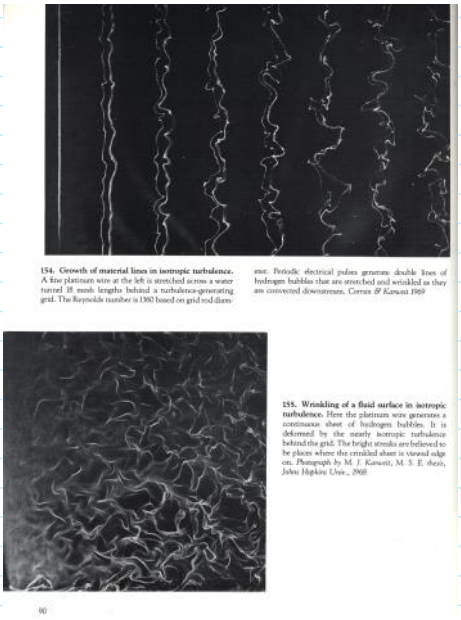
- Pine pollen (floats on surface)
- Lycopodium powder (also used as flash powder)
- http://vimeo.com/89491724 Cymatics

Susie Sie

Laser Doppler Velocimetry

Point meas of velocity

Want neutral buoyancy, but for very small particles viscous forces are high. Can use up to 100 µm particles. Good scatterers.



154. Growth of material lines in isotropic turbulence. A fine platinum wire at the left is stretched across a water tunnel 18 mesh lengths behind a turbulence-generating grid. The Reynolds number is 1360 based on grid rod diameter. Periodic electrical pulses generate double lines of hydrogen bubbles that are stretched and wrinkled as they are convected downstream. Corrsin & Kistler 1969

155. Wrinkling of a fluid surface in isotropic turbulence. Here the platinum wire generates a continuous sheet of hydrogen bubbles. It is deformed by the nearly isotropic turbulence behind the grid. The bright streaks are believed to be places where the crinkled sheet is viewed edge on. Photograph by M. J. Kaiser, M. S. E. thesis, Johns Hopkins Univ., 1968

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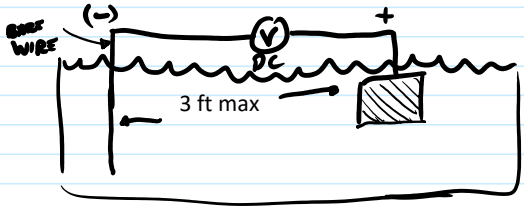
Van Dyke's Album of Fluid Motion

Hydrogen Bubbles



H_2 bubbles
anode

O_2 & Cl_2 bubbles
cathode

large plate or pipe

Smallest H2 bubbles if wire is very thin. Bubbles = 1/2 to 1 wire diameter = 25 to 50 µm

Want small enough bubbles to track flow, and have a slow rise time, so < 100 µm needed.
Best if wire is platinum. Other wires oxidize, and don't provide a clean sheet of bubbles.

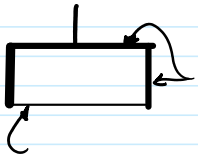
Minute paper: Why not use O2? $2H_2O \rightarrow 2H_2 + O_2$

For same current, get half as much O_2
diffusivity
relative solubility
surface tension

Need 50 - 70 VDC, 1 amp minimum.
For long wires (200 mm) need 250 V, 2 amps
Expensive power supply.

The water must conduct well.
Add salt. Some refs say sodium sulfate is better than sodium chloride, table salt.
Weak acid or base would also conduct, but may eat wire.

Too much salt = bigger bubbles, Cl gas?



Pt wire, tight and smooth. Big bubbles form at kinks.

Any ions in the water are attracted to the electrodes, so material plates onto the electrodes, fouls the wire.
"Cleaning" = Reverse polarity briefly now and then for a few seconds

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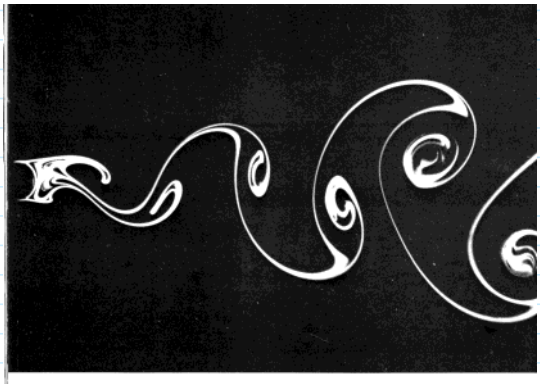
Electrolytic Precipitation Technique

- Same circuitry as H2 bubbles, but 10VDC, 10 mA. Much more reasonable requirements but….
  Tracer is electrolytically precipitated oxide at anode, of anode material.
  Metal often used = solder = tin+lead. Two heavy metals you don't want to put down the drain; needs 5 um filter.



94. Kármán vortex street behind a circular cylinder at R=140. Water is flowing at 1.4 cm/s past a cylinder of diameter 1 cm. Integrated streaklines are shown by electrolytic precipitation of a white colloidal smoke, illuminated by a sheet of light. The vortex sheet is seen to grow in width downstream for some diameters. Photograph by Sadatoshi Taneda

95. Kármán vortex street behind a circular cylinder at R=200. This photograph, made using a different fluid (and in another country) happens to have been timed so as to resemble remarkably the flow pattern in the upper picture. A thin sheet of tobacco smoke is introduced upstream in a low-turbulence wind tunnel. Photograph by Gary Koopmann

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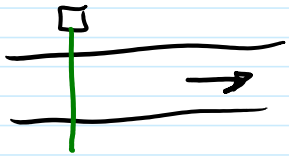
Latex Microbubbles.

If too dense, can be 'cooked' to expand to neutral buoyancy

Very expensive! $100 for a few grams worth.

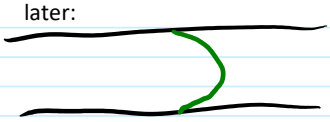
Molecular Tagging Velocimetry

Laser beam "uncages" dye along a beam line, which then deforms with the fluid:

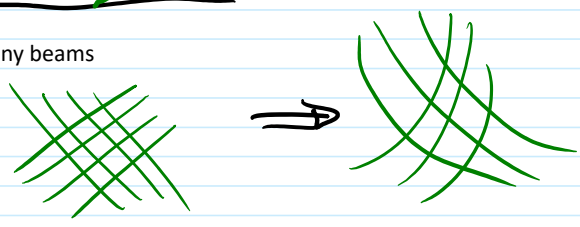


flow in a tube

later:



Many beams

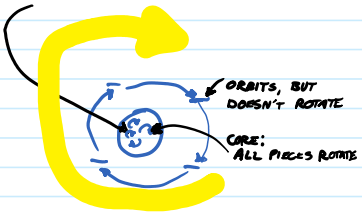


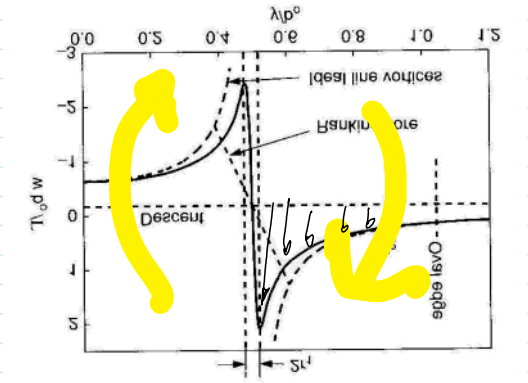
Can be quantified to measure velocity field.

Dye is molecular, no seed problems.

http://www.egr.msu.edu/tmual/MTV.html

Vorticity = rotation of a fluid element around its own middle
Vortical fluid = fluid with vorticity
Vortex = Vortical fluid (vortex core), often surrounded by irrotational (non -vortical) fluid





McLean, Doug. *Understanding Aerodynamics Arguing from the Real Physics*. Chichester: Wiley-Blackwell, 2013.

http://www.youtube.com/watch?v=loCLkcYEWD4 3:30 - 6 min, vorticity in boundary layer, then irrotational flow around bathtub vortex.
http://www.youtube.com/watch?v=JI0M1gVNhbw Parody of NCFMF