Last time, talked about dyes:
1) Don't disturb flow
2) High visibility: How does light interact with matter anyways?

2) Want dye to show up - HIGH VISIBILITY

High Visibility: Want good contrast between dyed and ambient fluid.

Ambient fluid = transparent = NO interaction with light
Dyed fluid = want MAXIMUM interaction with light

Minute paper: list the ways that dye (or any molecule) can interact with light (from external source, later will talk about emitted light)
4) Absorption

- Normal sight in white light; all colors (wavelengths) are absorbed except the one we see, which is diffuse reflected to our eyes

- Big 4: Refraction, reflection, diffraction, absorption.

- Dispersion, any of these, but
  - Affected differently based on wavelength
    - Leads to chromatic aberration, prisms, cloud iridescence (maybe diffraction around particles; interference)
    - Birefringence = 2 indexes of refraction

Make sure lighting and backdrop are appropriate for the type of light interaction.

E.g.:

Dye = dark food color. Absorption is primary, so use bright backdrop
Dye = milk. Scatter is primary; use black backdrop

Minute paper: Which is better for a dark backdrop: smooth or rough/matte?
Light Emitting fluids

**Black Body Radiation** = yellow flame color, from BBR of soot particles. Random $\lambda$ (wavelength) photons from thermal energy

**Luminescence** = cold body emission, usually at specific $\lambda$.

**Fluorescence** = absorption at a specific short $\lambda$, emits at a longer $\lambda$.

E.g. some laundry detergents and fabric softeners absorb in the UV, and emit blue or orange

Fluorescent bulbs: Current is conducted through mercury vapor, energizes it to emit UV photons which hit a phosphor coating on the inside of the tube, which then emits visible light.

3) Special Techniques

*Fig. 18.2. Spectral intensity distribution of Planck’s black-body radiation as a function of wavelength for different temperatures. The maximum of the intensity shifts to shorter wavelengths as the black-body temperature increases.*


Smooth is good if you can control what the specular reflection shows. If not, rough is better.
Chemoluminescence - Cyalume: chemical reaction releases photon, which then drives fluorescence. Needs mix of chemicals for reaction, and choice of color. Flames: \( \text{C}_2, \text{CH} \), radicals = highly reactive intermediate molecules (between reactant and product species) that only exist in the thin reaction zone. Excited by reactions, emit blue photons to get to lower energy state. Also, hot soot gives off black body radiation; yellow glow.

Electroluminescence - LEDs, sodium vapor, mercury vapor lamps etc. Specific \( \lambda \).

Laser - population inversion, specific \( \lambda \), resonant cavity with mirrors. Gas dynamic laser: after supersonic expansion, lower vibrational states relax before higher ones = inversion. A type of ’chemical laser’

Bioluminescence - Fireflies, deep sea fish, worms. Good for flow vis?

II Particles

Heavy seeding
Number density high enough to look like a dye.

Similar considerations to dyes:
1) Particles must track with the flow
**Heavy seeding**

Number density high enough to look like a dye.

Similar considerations to dyes:
1) Particles must track with the flow. Dyes are molecules, track with the flow just fine.
2) Want particles to NOT disturb flow.
3) Want particles to show up - HIGH VISIBILITY

1) When will particles track well, be good tracers?

Minute paper: Consider a curved streamline. Consider a small particle, much denser than the fluid, but small enough that gravity is negligible compared to forces of the fluid on the particle. (diameter ~ 100 µm in water)

What will the particle path look like compared to the fluid path?

Next, consider same scenario, but a bubble instead of a particle.

For particles (or bubbles) to track with the surrounding fluid, they must accelerate the same as the neighboring fluid.

**Forces on particle:**
- **Body:** gravity, neglect.
- **Surface:** normal + pressure, parallel = shear

First, assume a pressure gradient:

Low Pressure

**Particle**

High Pressure

Net Force

Low Pressure

**Fluid**

High Pressure

Same Net F

Which particle will accelerate more?
Newton’s Second Law: \( \sum F = ma \)
What makes streamlines curve?

Streamlines curve because of pressure gradient. Low P is inside curve.

(fluid path)

(what is a streamline?)