# 18B.LightEmittingFluids

Wednesday, November 7, 2018

Today: Light emitting fluids (last of dye/molecular techniques), then particles as seed.

## Recap, Dye Techniques

Want dye to have strong interaction with light, to create contrast to unseeded fluid.
How does dye, or any matter interact with light?

1) Reflection
2) Refraction
3) Diffraction
4) Absorption

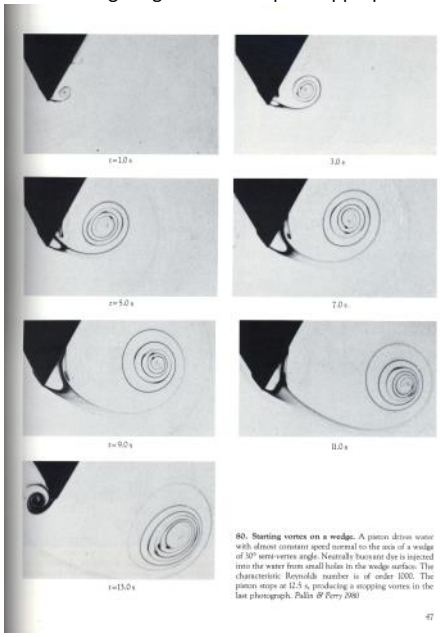
**4) Absorption**

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

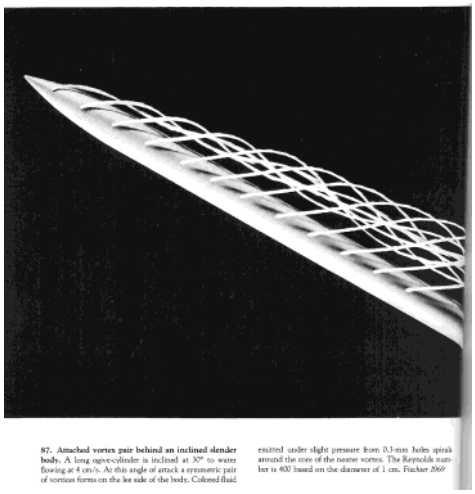
- Dispersion, any of these, but
  - Affects differently based on ***wavelength***
    - leads to chromatic aberration, prisms, cloud iridescence (maybe diffraction around particles; interference)
    - Birefringence = 2 indexes of refraction

http://www.ualberta.ca/~pogosyan/teaching/PHYS_130/FALL_2010/lectures/lect35/lecture35.html

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



80. Starting vortex on a wedge. A piston drives water with almost constant speed normal to the axis of a wedge of 30° semi-vertex angle. Neutrally buoyant dye is injected into the water from small holes in the wedge surface. The characteristic Reynolds number is of order 1000. The piston stops at 12.5 s, producing a stopping vortex in the last photograph. *Pullin & Perry 1980*



87. Attached vortex pair behind an inclined slender body. A long ogive-cylinder is inclined at 30° to water flowing at 4 cm/s. At this angle of attack a symmetric pair of vortices forms on the lee side of the body. Colored fluid emitted under slight pressure from 0.3-mm holes spirals around the core of the nearer vortex. The Reynolds number is 400 based on the diameter of 1 cm. Fiechter 1969

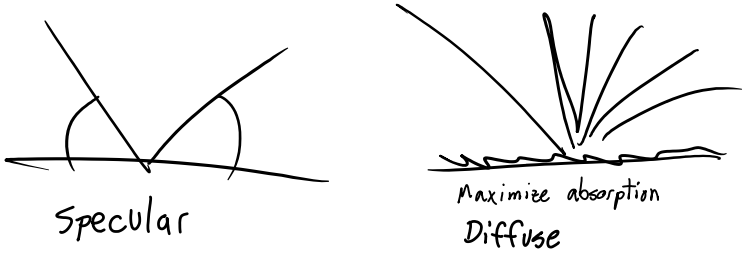
E.g.:
Dye = dark food color. Absorption is primary, so use bright backdrop
Dye = milk. Scatter is primary; use black backdrop

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

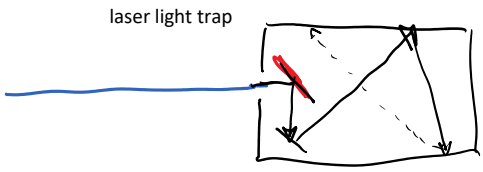
A) Smooth
B) Matte
C) It depends

Matte - not shiny - no specular reflection

Depends - on whole environment,
can specular reflection be managed?




Smooth is good if you can control what the specular reflection shows. If not, rough is better.



## For maximum absorption:

**Vantablack** is the trademarked name (owned by Surrey NanoSystems Limited)[1] for a chemical substance made of vertically aligned carbon nanotube arrays[2] and is one of the darkest artificial substances[3] known, absorbing up to 99.965% of radiation in the visible spectrum.[4][5]

From <https://en.wikipedia.org/wiki/Vantablack>

Vantablack S-VIS, a sprayable paint that uses randomly-aligned carbon nanotubes and only has high absorption in the visible light band, has been exclusively licensed to Anish Kapoor's studio for artistic use.[18] This has caused outrage among some other artists, including Christian Furr and Stuart Semple.

From <https://en.wikipedia.org/wiki/Vantablack#Exclusive_licence_within_arts>

### 3) Special Techniques

**Light Emitting fluids: Photons are emitted for a range of reasons.**

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

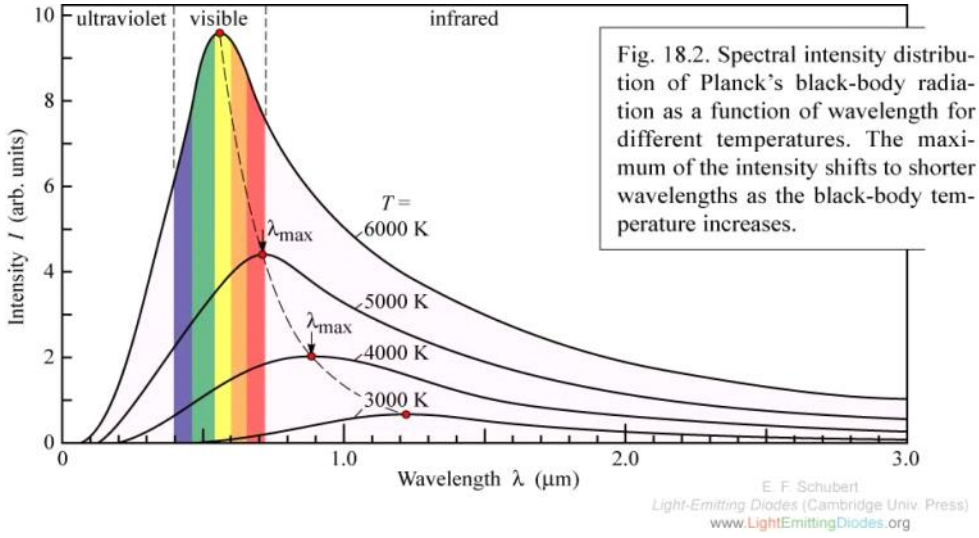


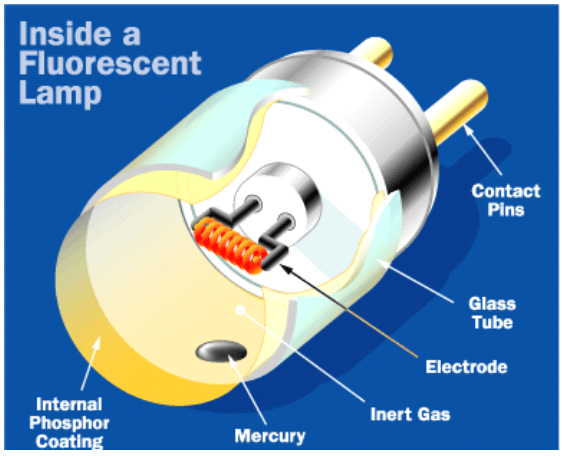

Fig. 18.2. Spectral intensity distribution of Planck's black-body radiation as a function of wavelength for different temperatures. The maximum of the intensity shifts to shorter wavelengths as the black-body temperature increases.

https://www.phy.questu.ca/rknop/classes/enma/2010-10/wiki/images/8/84/Black_body.jpg

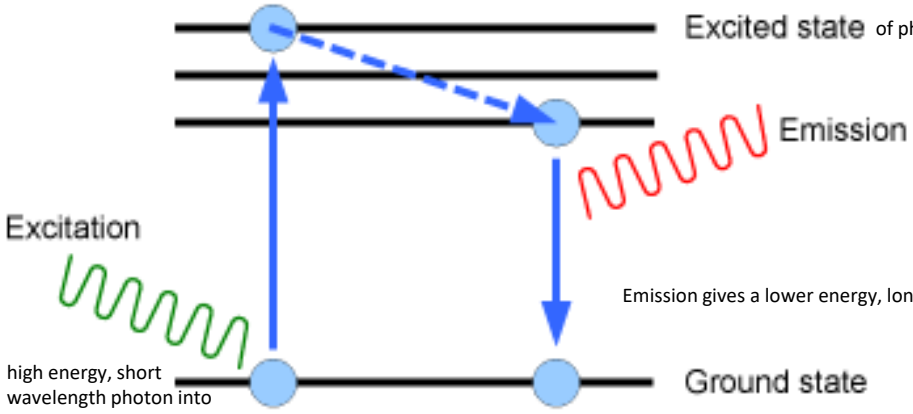
***Luminescence*** = cold body emission, usually at specific λ.
***Fluorescence*** = absorption of photons at a specific short λ, emits at a longer λ.

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.




http://home.howstuffworks.com/fluorescent-lamp.htm/

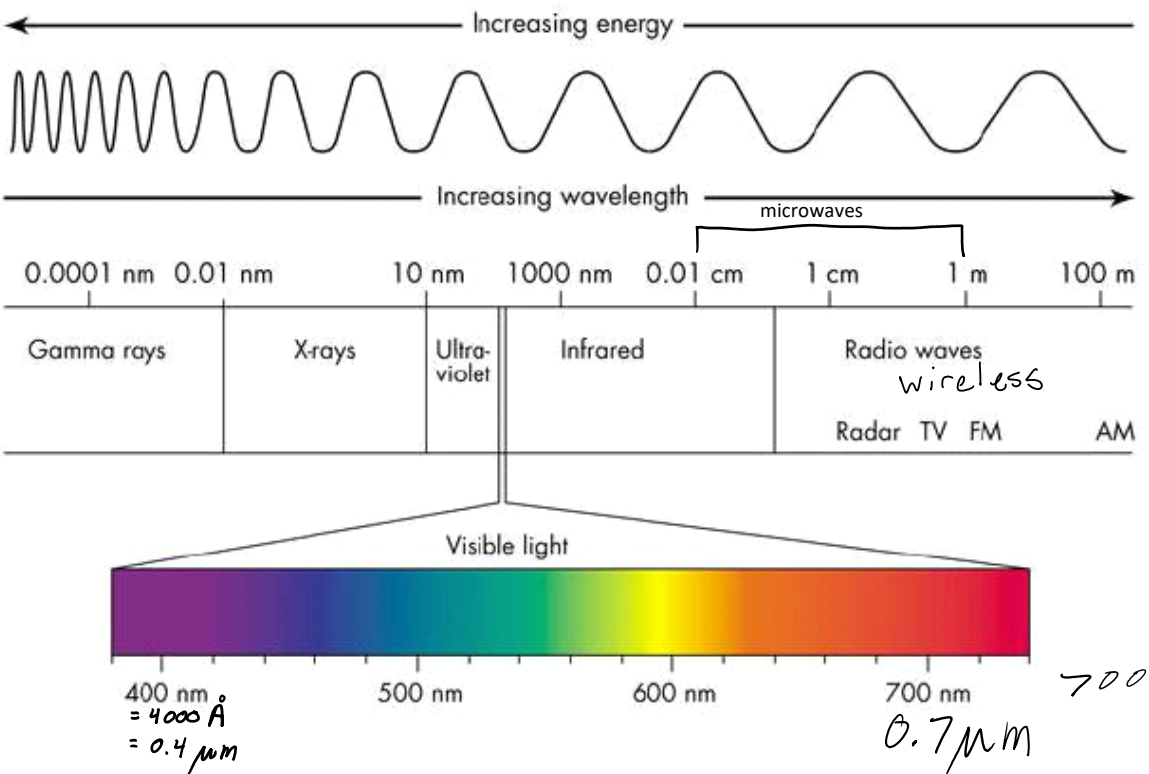



http://www.art.ca/en/preclinical/optical-molecular-imaging/fluorescence.php

Wavelength change between absorption and emission = Stokes shift:

- some heat lost from excited state,
- and/or returns to ground state + highest vibrational mode, not all the way down.

**EM spectrum review**




http://lumenistics.com/what-is-full-spectrum-lighting/

Flames: $H_3C + O_2 \xrightarrow{C_2^+, CH} CO_2 + H_2O + C_6$ soot

***Chemoluminescence*** - Cyalume, party bracelets: chemical reaction releases photon, which then drives fluorescence. Needs mix of chemicals for reaction, and choice of color.
Flames: $C_2$, $CH^+$ , 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.
http://www.sciencefriday.com/video/06/08/2012/what-is-a-flame.html

***Bioluminescence*** - Fireflies, deep sea fish, worms. Good for flow vis? Ocean Wakes plankton Life of pi
https://www.youtube.com/watch?v=Fvob6L8q3I8 Red tide, blue waves off San Diego

***Electroluminescence*** - LEDs, sodium vapor, mercury vapor lamps etc. Specific λ.

E.g. electric pickle http://www.youtube.com/watch?v=tMhXCG6k6oA

***Laser*** : population inversion, specific λ, resonant cavity with mirrors. Gas dynamic laser: after supersonic expansion, lower vibrational states relax before higher ones = inversion. A type of 'chemical laser'