Lecture #7 – More on Criticality & Critical Assemblies
(and some related topics)
The world’s first man-made reactor

- Chicago Pile 1 (CP-1), Enrico Fermi et al.
- Built in the squash courts under Alonso Stagg Field, University of Chicago
- Achieved criticality December 2, 1942
- Natural Uranium (0.71% $^{235}\text{U}$); 5.4 tons U metal, and 45 tons UO$_2$
- Graphite core 7.6 m across x 6.1 m high; 360 tons, high purity (Acheson Graphite)
- Thermal power, 5 Watts
A thoughtful gift from my NE-201 students Sp-2017
The Louis Slotin criticality accident (Los Alamos, May 21, 1946)
Dramatization in “Little Boy and Fat Man” (1989)  
https://www.youtube.com/watch?v=AQP7R9CfCY

Louis Alexander Slotin (December 1, 1910 – May 30, 1946)
The Rayleigh-Taylor Instability

- Lord Rayleigh, G.I. Taylor
- Whenever a denser fluid is being pushed or accelerated by a less dense fluid, any perturbations will grow exponentially.
- The characteristic ‘mushroom cap’ features eventually become fractal at all length scales.
- The phenomenon is ubiquitous: the cream in your morning coffee, astrophysical nebulae, spherical implosions (e.g. the primary of a nuclear weapon), fusion capsules.
- In fact, it is the bane of both fission and fusion; the Trinity Test was hastily redesigned after Taylor gave a seminar at Los Alamos in May 1945, shocking Oppenheimer.

https://www.youtube.com/watch?v=bW4526vHnY0  https://www.youtube.com/watch?v=yabqo7VFTYs
Hydrodynamic (bomb core) test on a firing table at Site 300, 1961. The bright "streaking" effect in the photo is likely from shards of pyrophoric metal, such as Uranium 238, hurtling through the air. U-238 is one of the contaminants of concern in the Site 300 Superfund cleanup. Photo: LLNL.
Those are the Rayleigh-Taylor fingers!
Richtmeyer-Meshkov Instability *(same thing, except under shock)*


Performed at LANL shock tube facility, using SF6 curtain setup

Series (a) : Mach 1.2

Series (b) : Mach 1.5
Kelvin-Helmholtz Instability (shear $\rho_2 \neq \rho_1$)

Again, a ubiquitous phenomenon in every day life:

(Upper left) Cirrus clouds

(Lower left) Surface of Saturn (NASA)

(Above) Ocean thermoclines at 500 m

https://www.youtube.com/watch?v=qEGbzZM0Baw  https://www.youtube.com/watch?v=UbAfvcaYr00
Neutron cross sections for $^{235, 238}$U