Problem 13
Pickle Night Light

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Abrego, Ceja, Hathaway, Kadam, Mal, Mehrotra

Sending Current Through Pickle

- U.S Outlets: 120V at 60 Hz
- Electrodes heat up to at least 100 C before light emission occurs
- Inside pickle small pockets of chlorine and hydrogen gas form near negative electrode
    - Analogous to electrolysis
    - Electrode polarity irrelevant if only concerned with temperature of metal
- Hydrogen gas layer is small and behaves as an insulator
    - Spark generated across layer
    - Sodium is thermally excited

Problem Statement

- If you pass a current from a conventional household wall socket through a pickle, it will glow. Investigate this effect, including the effect of alternating currents, and the use of multiple pickles in a chain. What is the mechanism (and time) for a pickle to die out?

What is a Pickle?

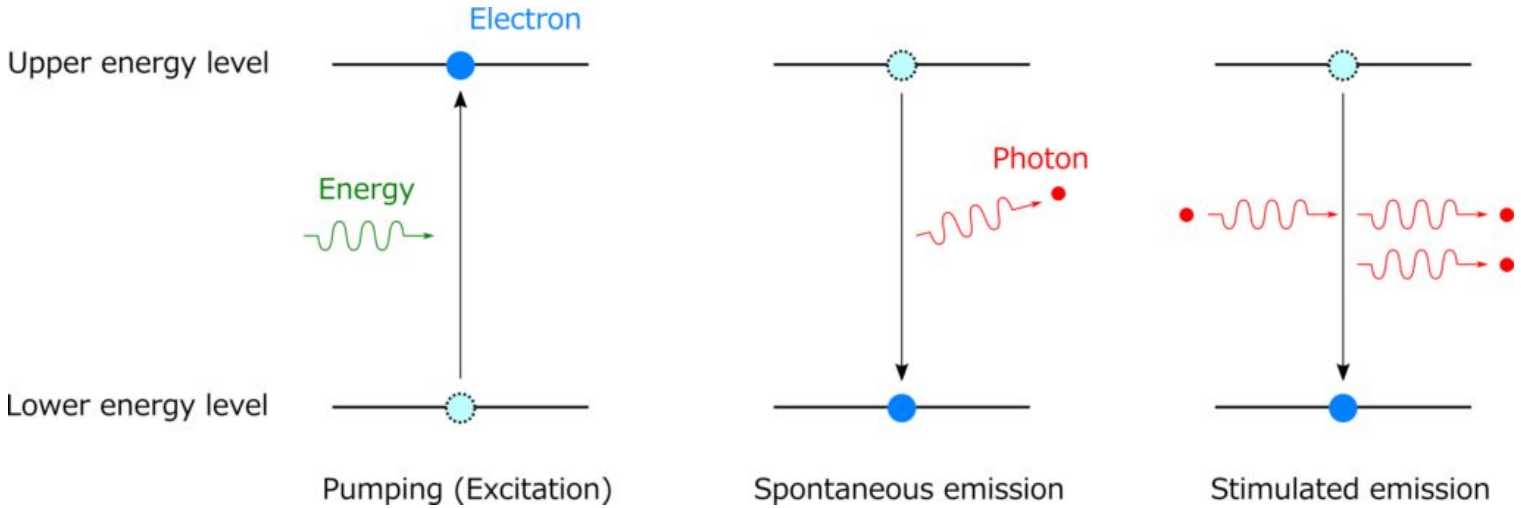
- A pickle is a cucumber marinated in a brine solution over an extended period of time. The brine solution consists of aqueous Sodium Chloride and Acetic Acid (Vinegar).
- The cucumber is subjected to extreme conditions (low pH, low oxygen levels, and high saline concentrations) resulting the growth of extremophile bacteria.

- *Main Take Away:* By pickling the cucumber, we increase the conductivity and introduce foreign species (mainly ions) into our system.

Example: Demonstration showing conductivity of salt water

Atomic System

- Pickle acts as bath for two level system and thermal energy deposits energy into system
- Similar to stimulated emission, but excitation due to thermal energy rather than photon
- If sufficient energy exists, sodium ion electron excited from ground to higher state
    - Falls back to lower energy after period of time



Atomic Theory (For reference)

- Entire system and mechanics defined by Hamiltonian
  - First term defines sodium ion
  - Second term defines thermal energy of bath
  - Third term defines interaction of energy with ion

$$H = H_{Na} + H_{thermal} + H_{Interaction}$$

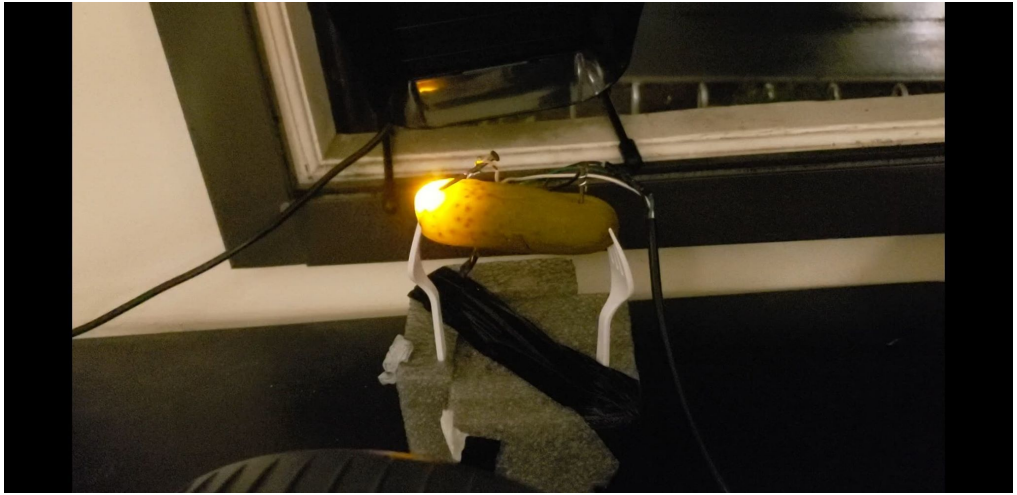
- Compare with dynamics of two level system due to externally applied field used to drive transitions (**This is optically driven, just for an analogy not directly applicable to sodium ions)**

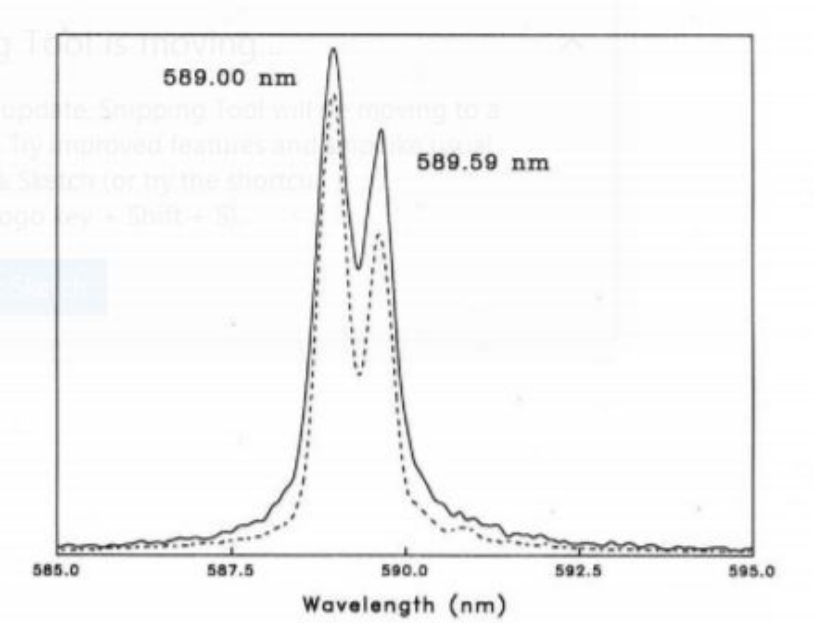
$$H_S = -\hbar\delta|2\rangle\langle 2| + \hbar\Omega^*|1\rangle\langle 2| + \hbar\Omega|2\rangle\langle 1|$$

$$\dot{\rho}_S = -\frac{\gamma}{2}(\bar{n}+1)\left(\sigma_{22}\rho_s - \sigma_{12}\rho_S\sigma_{21} + h.c.\right) - \frac{\gamma}{2}\bar{n}\left(\sigma_{11}\rho_S - \sigma_{21}\rho_S\sigma_{12} + h.c.\right) + \frac{1}{i\hbar}[H_S, \rho_S]$$

Emission of Light

- Photon emitted from electron dropping energy level has wavelength corresponding to energy required to excite it
- Two main wavelengths of light emitted
    - 589.00 nm and 589.59 nm





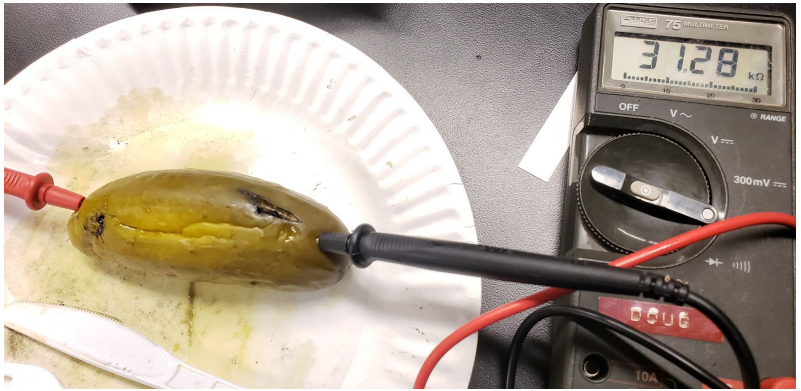
Cool Part
Glowing Pickle Experiments

Experimental Procedures

Experimental Setup

1. Measure resistance of pickles out of jar
2. Place on stand near ventilation
3. Wall plug stripped and inserted into pickle
    a. Live and Neutral Wire inserted on ends (attached to electrodes)
    b. Ground tied down/floating
4. Plug into wall
    a. Record video
    b. Observe glow and near which electrode

- Single Pickle
- Pickle Chain
    - 3 Pickle Chain



Single Pickle

- 6 trials done
  - First failed due to regulators in extension cords being used
  - Also due to set up of wiring to wall
  - Attempted to maintain safe environment
- Pickles began sparking due to rough edges on nails used for electrodes
  - This is when trials would be cut short

Pickle Chain

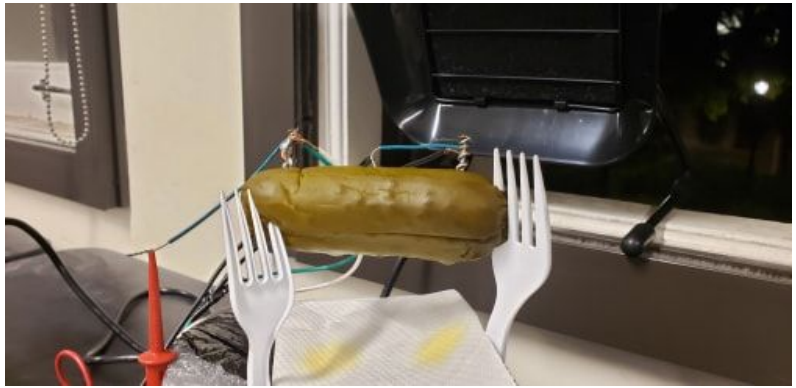
- 3 pickles attached together with flat electrodes in between
- Only pickle on live wire glowing
- Indication of polarity effects on glow
- Potentially did not wait long enough for any other pickle to glow
    - Other demonstrations of same setup show center pickle glowing

Additional Observations

Resistances for single pickle

Pickle #	Resistances (kΩ)	Successful
1	203.5 +/- 5	No
2	199.9 +/- 5	Yes
3	≈25 +/- 5	Yes
4	≈10 +/- 5	Yes
5	≈20 +/- 5 , ≈6 +/- 5	Yes
6	≈20 +/- 5 , ≈25 +/- 5	Yes

Additional Images



Conclusion