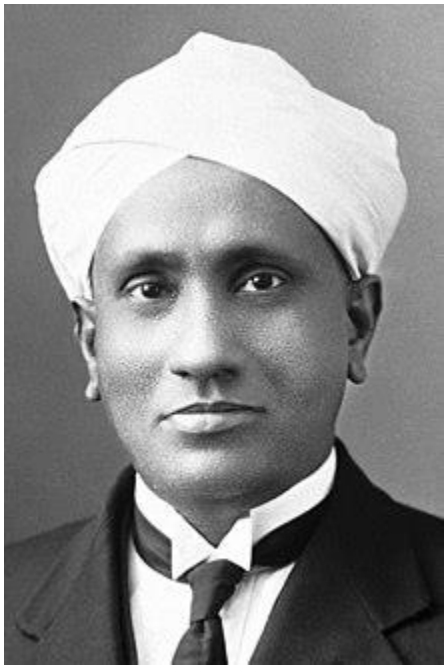
Raman Spectroscopy

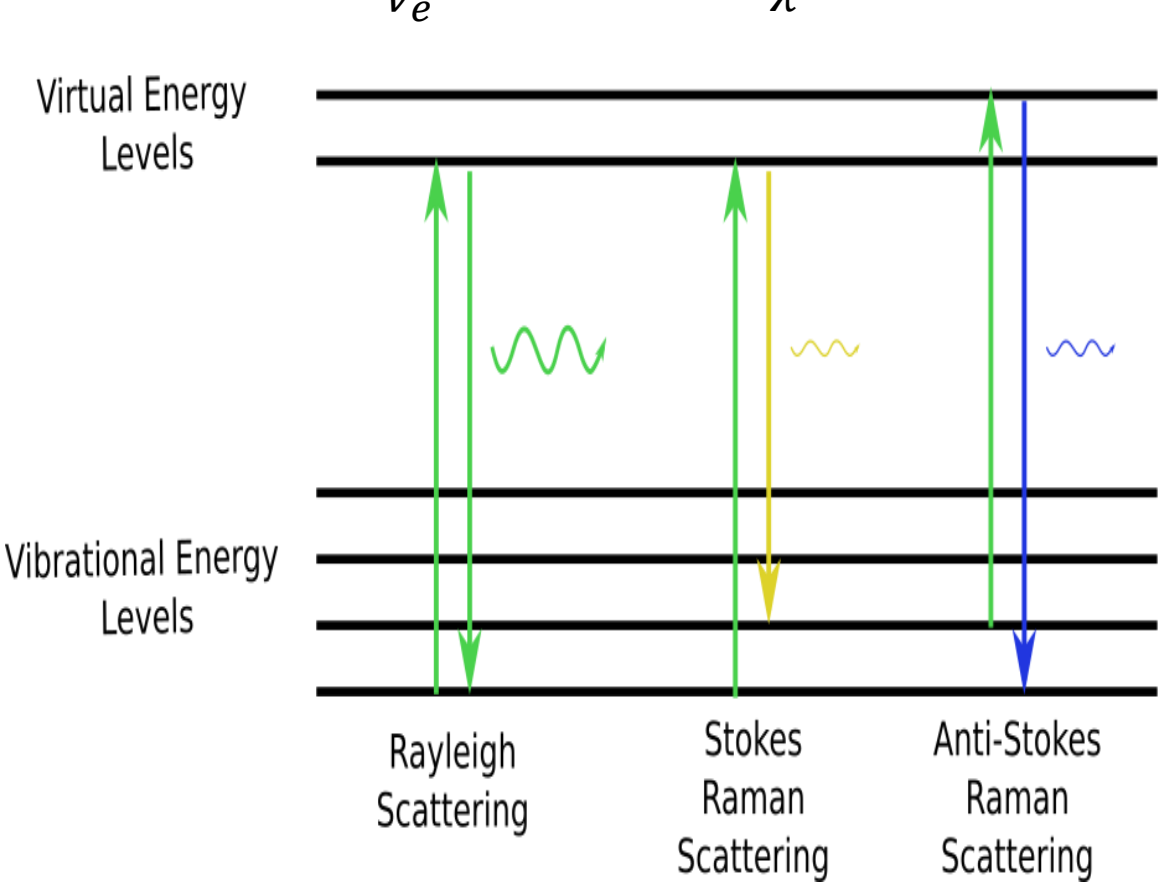
Not ramen….

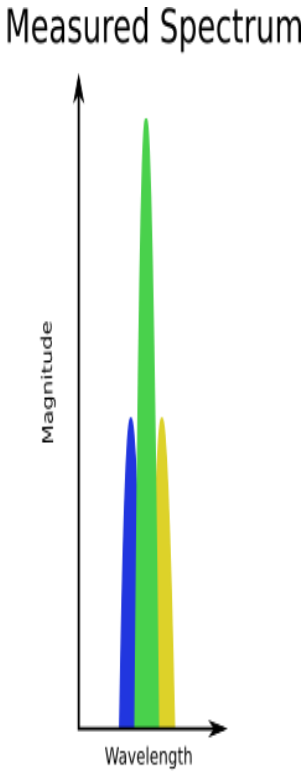


Chandrasekhara Venkata Raman
He got the Nobel prize for this in 1930.
This will be even more impressive at the end

What is Raman Spectroscopy?

- Nonlinear interaction between light and the matter being probed
  - What's a nonlinear interaction?
- Only works on molecules that are polarizable
  - What materials are polarizable?
- $I_R \propto \frac{(\nu_L - \nu_{vib})^4}{\nu_e}$ or $I_r \propto \frac{1}{\lambda^4}$





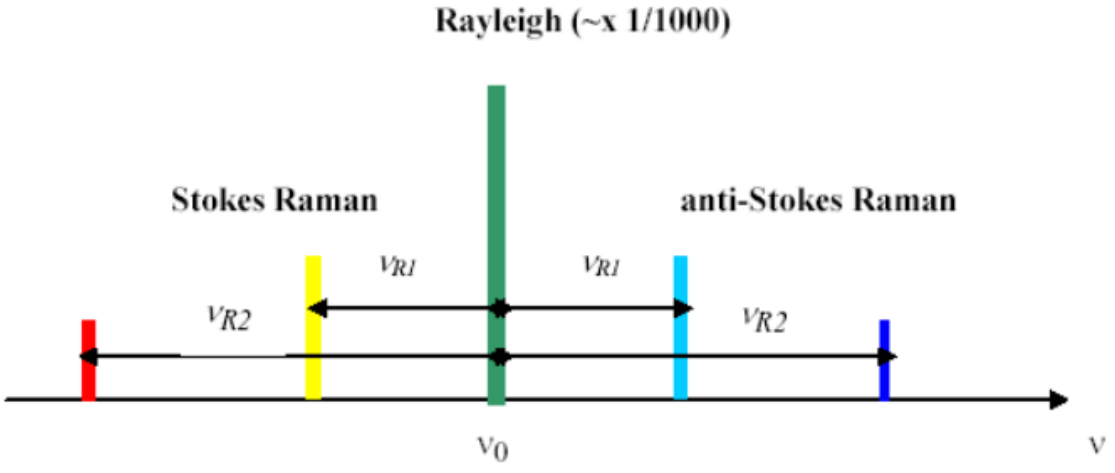
Raman scattering

- Classically, the Raman and Rayleigh effects can be described by the polarizability of a molecule
- The induced dipole μ can be written
  $\mu = \alpha E$; (1)

  α is the polarizability of the molecule: $(\alpha_0 + \beta \sin 2\pi \nu_R t)$
  E is the applied field: $(E_0 \sin 2\pi \nu t)$
- If E is a travelling light wave at frequency ν, and amplitude E_0, then $\mu = (\alpha_0 + \beta \sin 2\pi \nu_R t) E_o \sin 2\pi \nu t$ (2)
  where ν_R is the vibrational frequency of the molecule.

Raman scattering

- Using common trigonometric relations, Eq. (2) can be written as;
- $\mu = \alpha_o E_o \sin 2\pi \nu t + 1/2\beta_o E_o\{\cos 2\pi(\nu - \nu_{vibr})t - \cos 2\pi(\nu + \nu_{vibr})t\}$
- ν_{vibr} is species specific, and so is the Raman shift

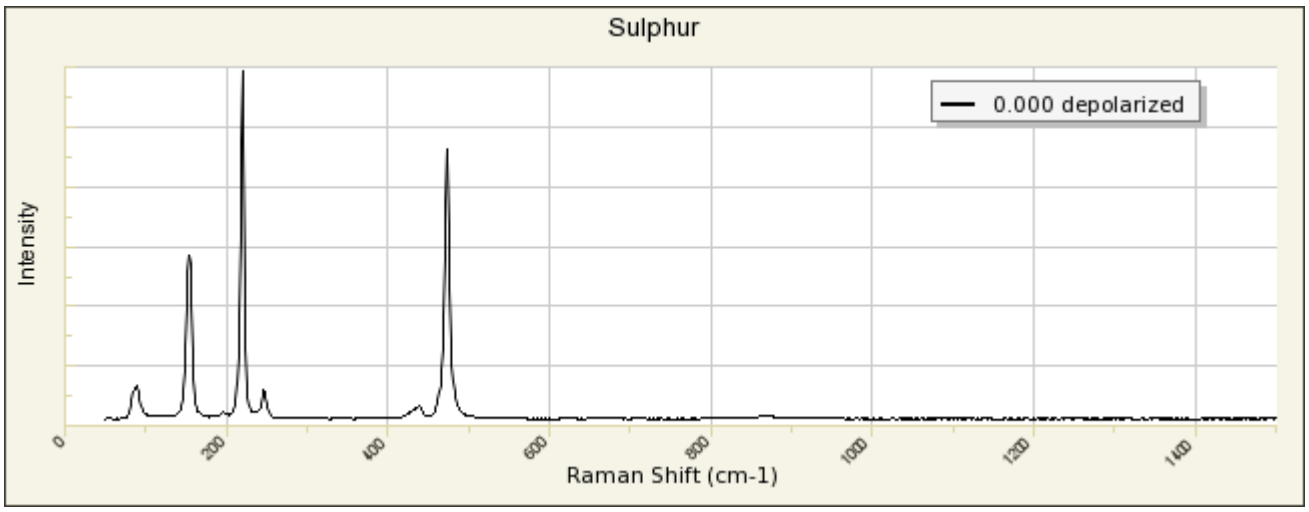


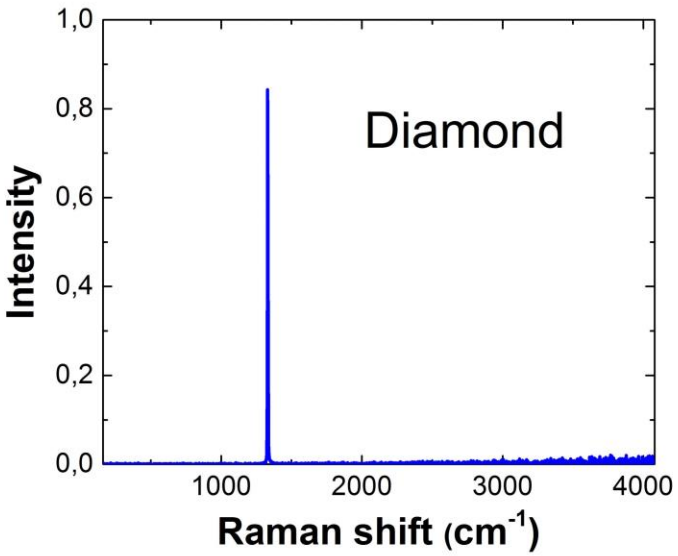
Lets look at some equations

https://cefrc.princeton.edu/sites/g/files/toruqf1071/files/Files/2011%20Lecture%20Notes/Alden/Lecture-8-Raman.pdf

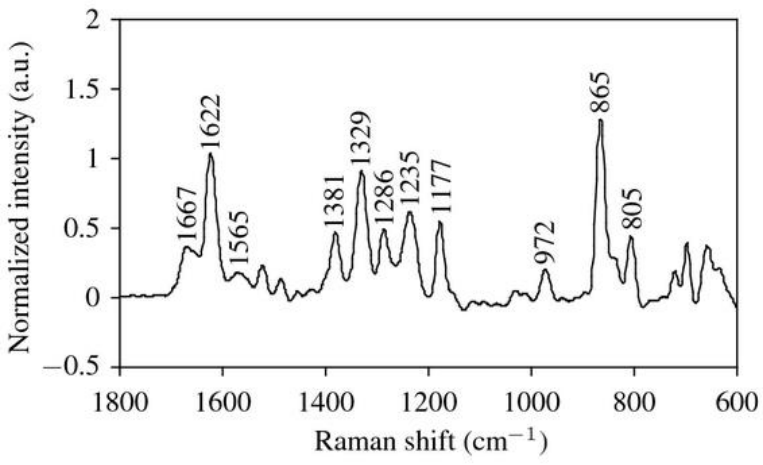
Alright what's the point of this?

- Many materials have identifiable Raman "fingerprints"
- You can use it to shift lights wavelength to something else



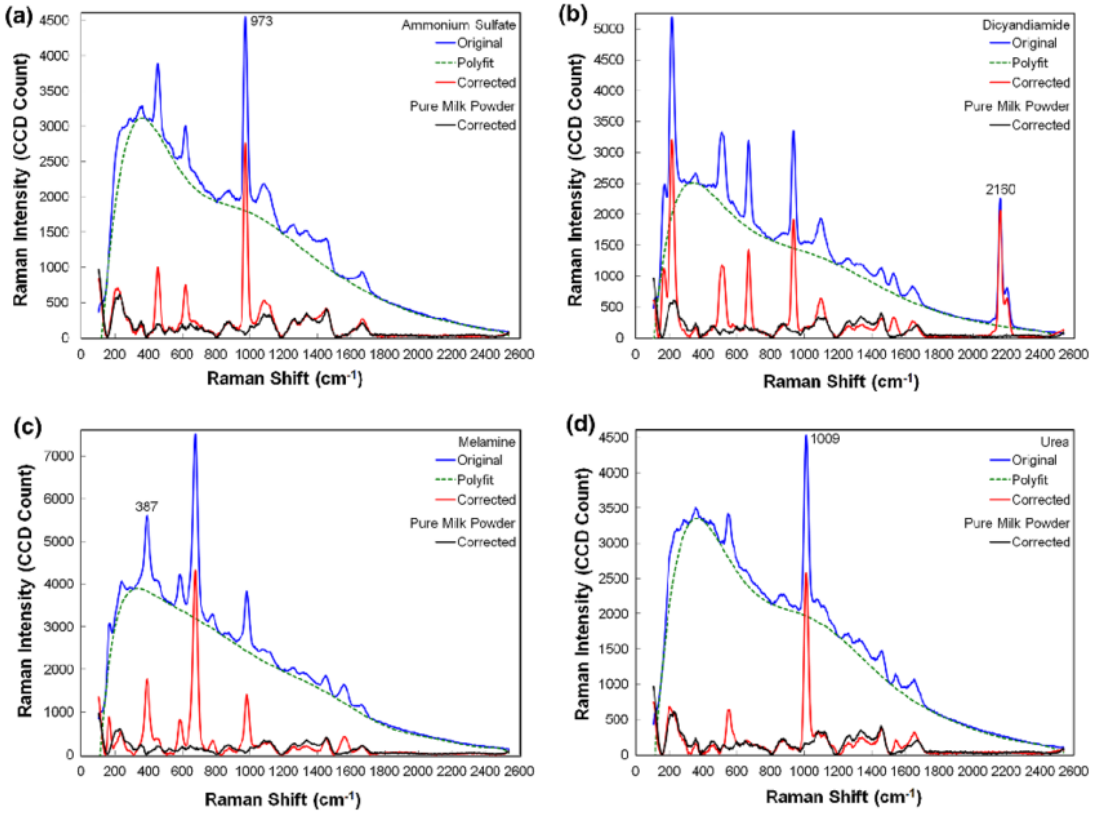


tylenol



What's the catch?

- Raman scattering is incredibly weak
- Raman scattering is almost a thousand times weaker than Rayleigh scattering
- It can often be overwhelmed by the fluorescence spectrum of the analyte
- You need very sensitive detectors, spectrometers often use ICCDS and or cool the detector to lower thermal noise



Simple setup