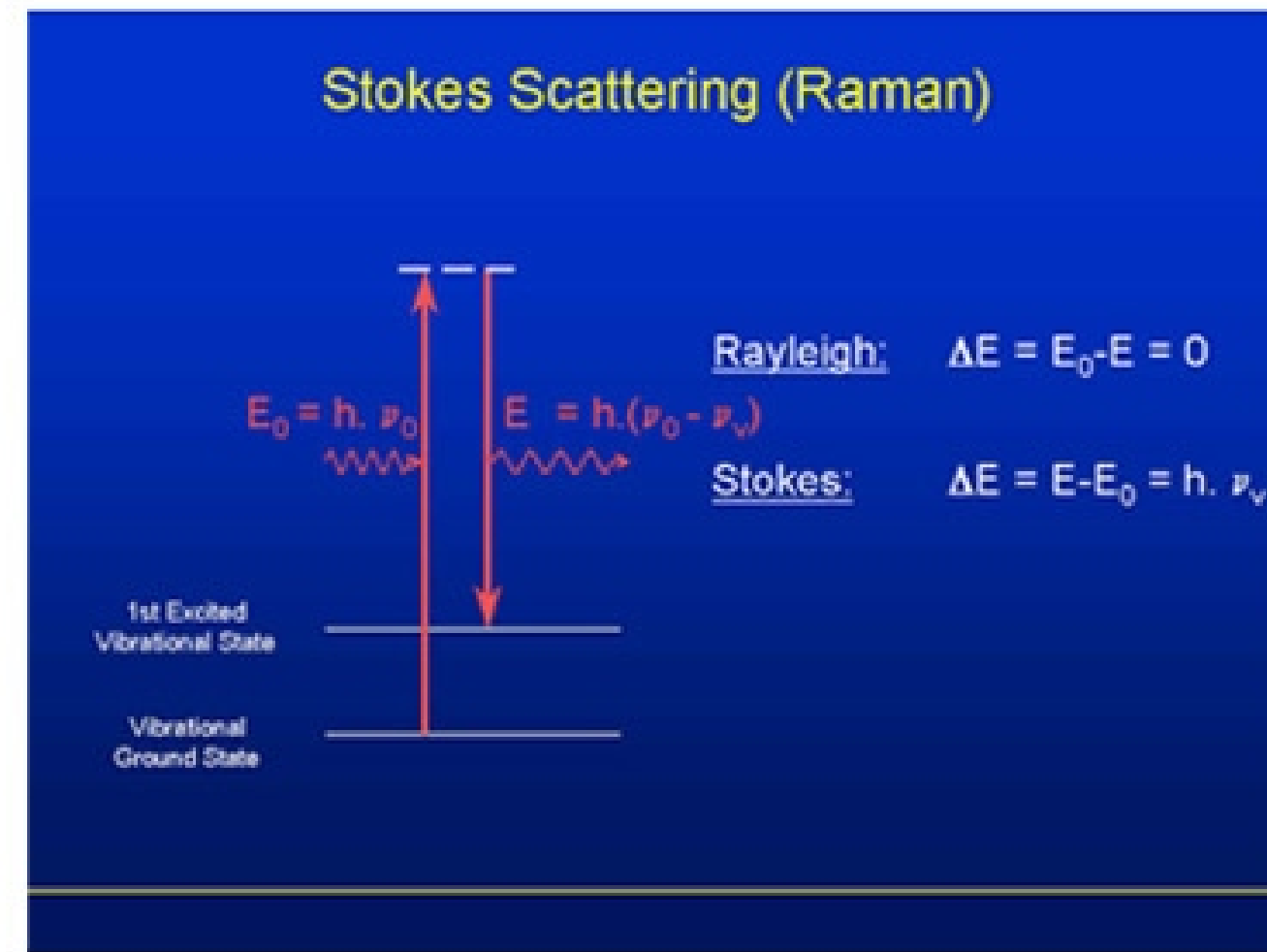


Raman Spectroscopy and LabVIEW

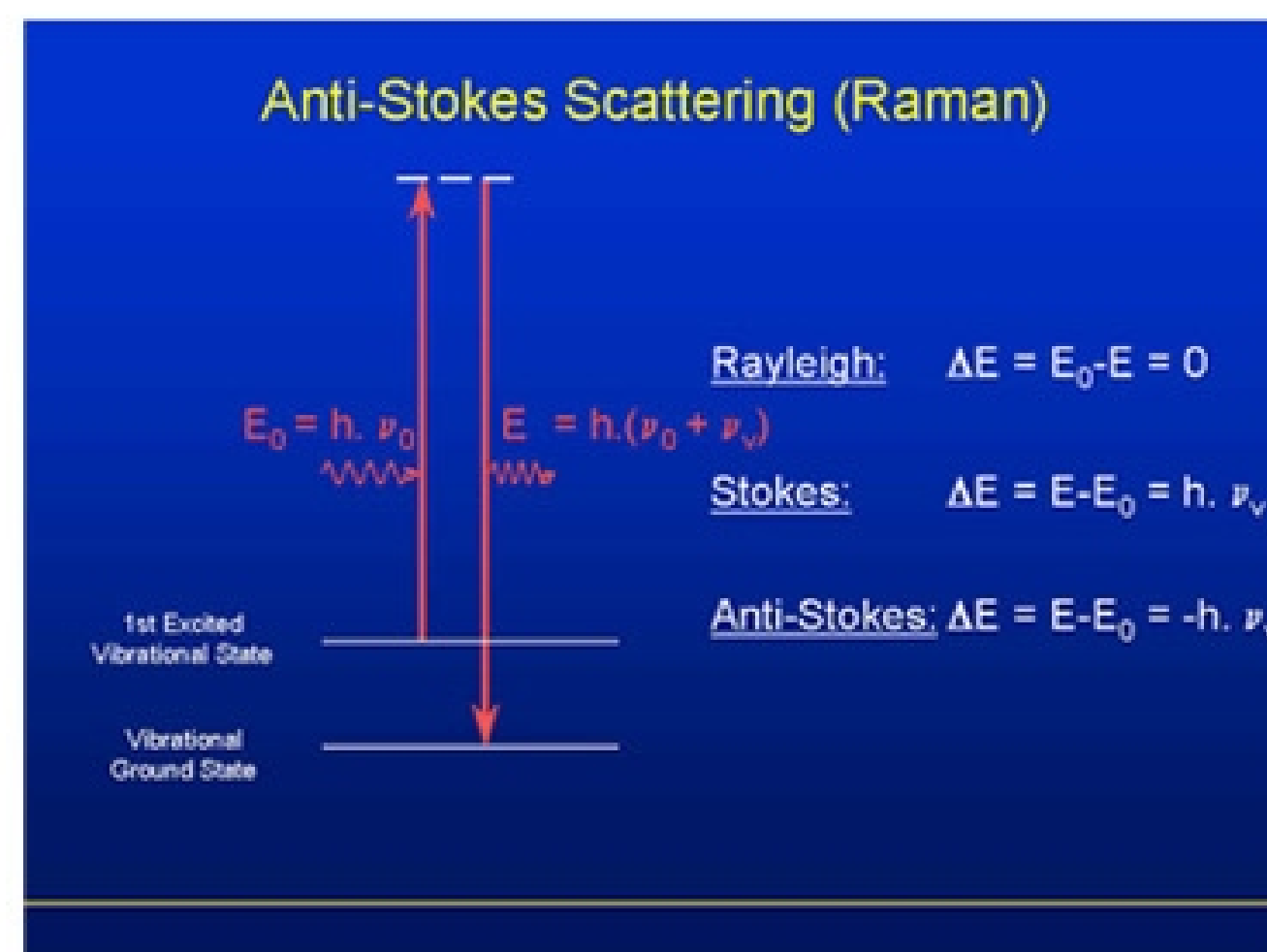
Stoke

Stokes Raman scattering occurs when the molecule is excited to a virtual level by absorption of a photon ($E_0 = h\nu_0$). The molecule returns to the first excited vibrational state and emits the energy difference as a photon with lower energy ($E = h(\nu_0 - \nu_v)$). This results in a higher wavelength than the incident wavelength.



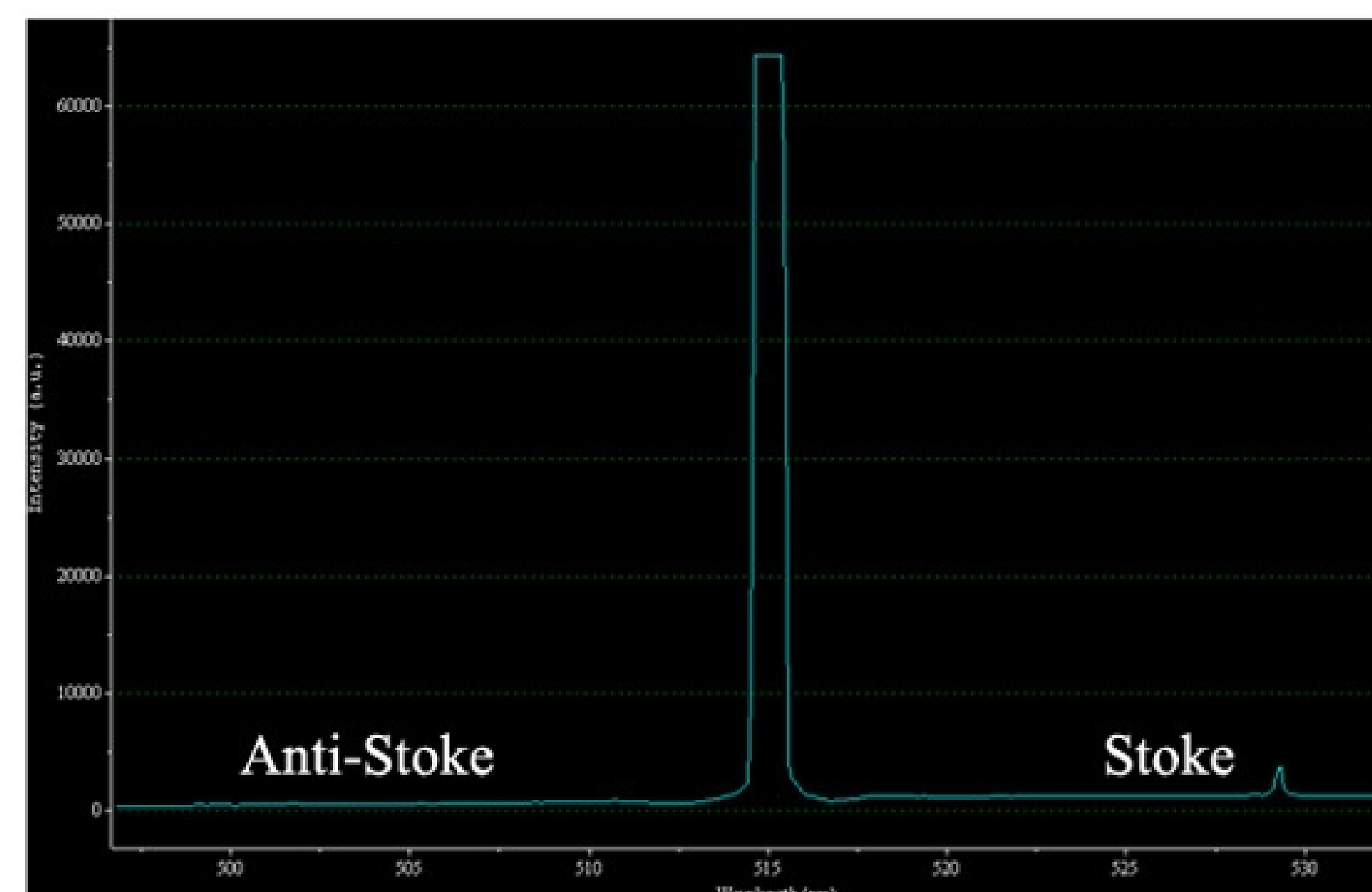
Anti-Stoke

Raman anti-Stoke scattering is when the molecule originates on the first excited vibrational level, and absorbs a photon with energy $E_0 = h\nu_0$. The molecule is excited to a virtual energy level, which is higher in energy than is the case with Stokes. The molecule returns to the vibrational ground state, emitting the energy difference as a photon with energy $E = h(\nu_0 + \nu_v)$. This results in light with a shorter wavelength than the incident light.



Spectrum of Raman

The output of a Raman system is a plot of scattered-light intensity as a function of frequency shift in which the shift is calculated relative to the monochromatic laser source frequency.

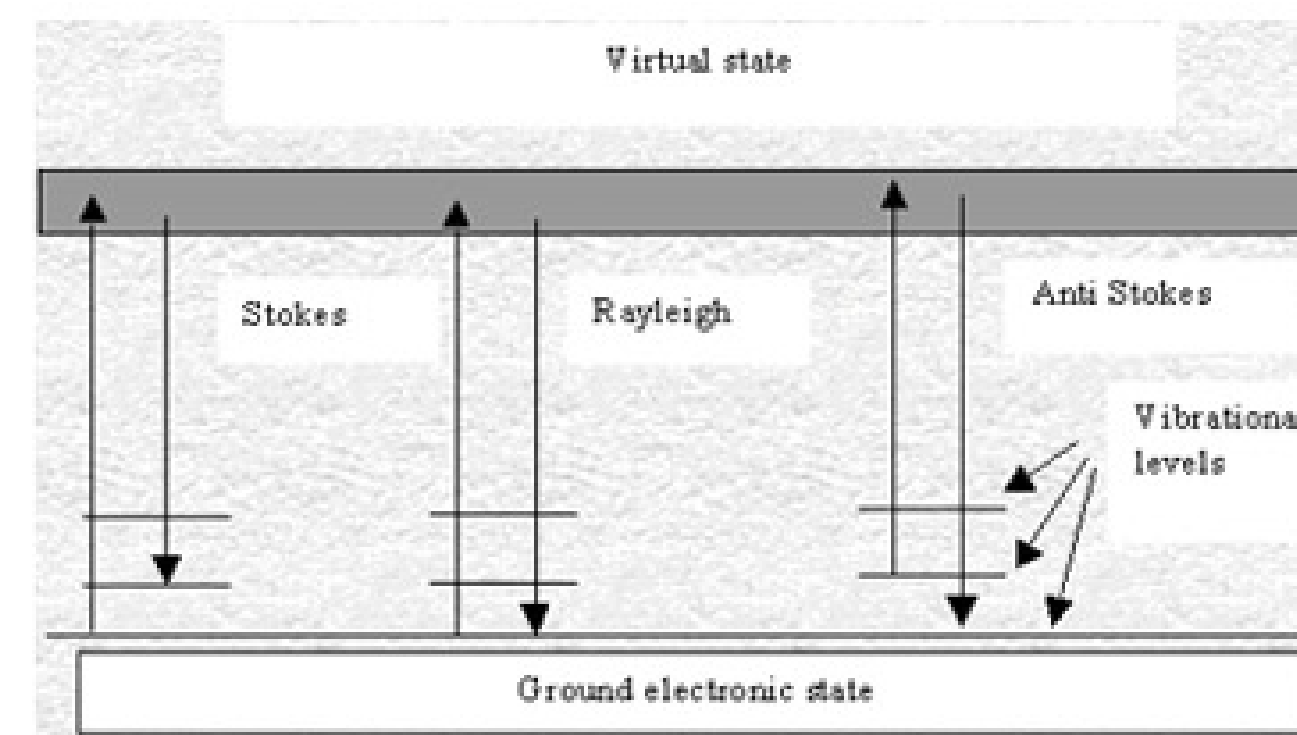


Theory of Raman

Raman spectroscopy is a technique that measures the temperature of a sample by irradiating the specimen with light of one wavelength to examine vibrational modes of a molecule.

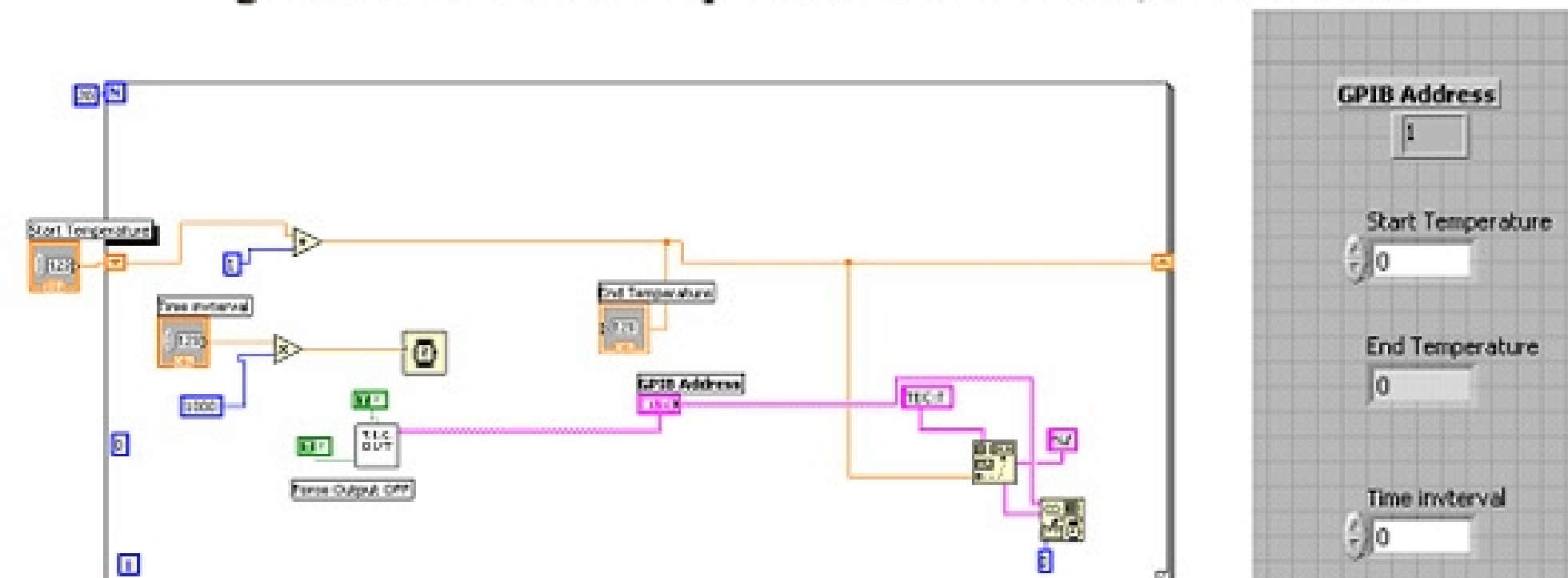
When light hits a molecule, the energy of the photons causes some lattice vibrations specific to the material of the specimens. This causes both elastic and inelastic scattering.

The majority of these scattered photons have exactly the same wavelength as the incident photons known as Rayleigh scatter, but approximately 1 in 10^7 of the scattered radiation is shifted to a different wavelength. The scatter of shifted photons is called Raman scatter.

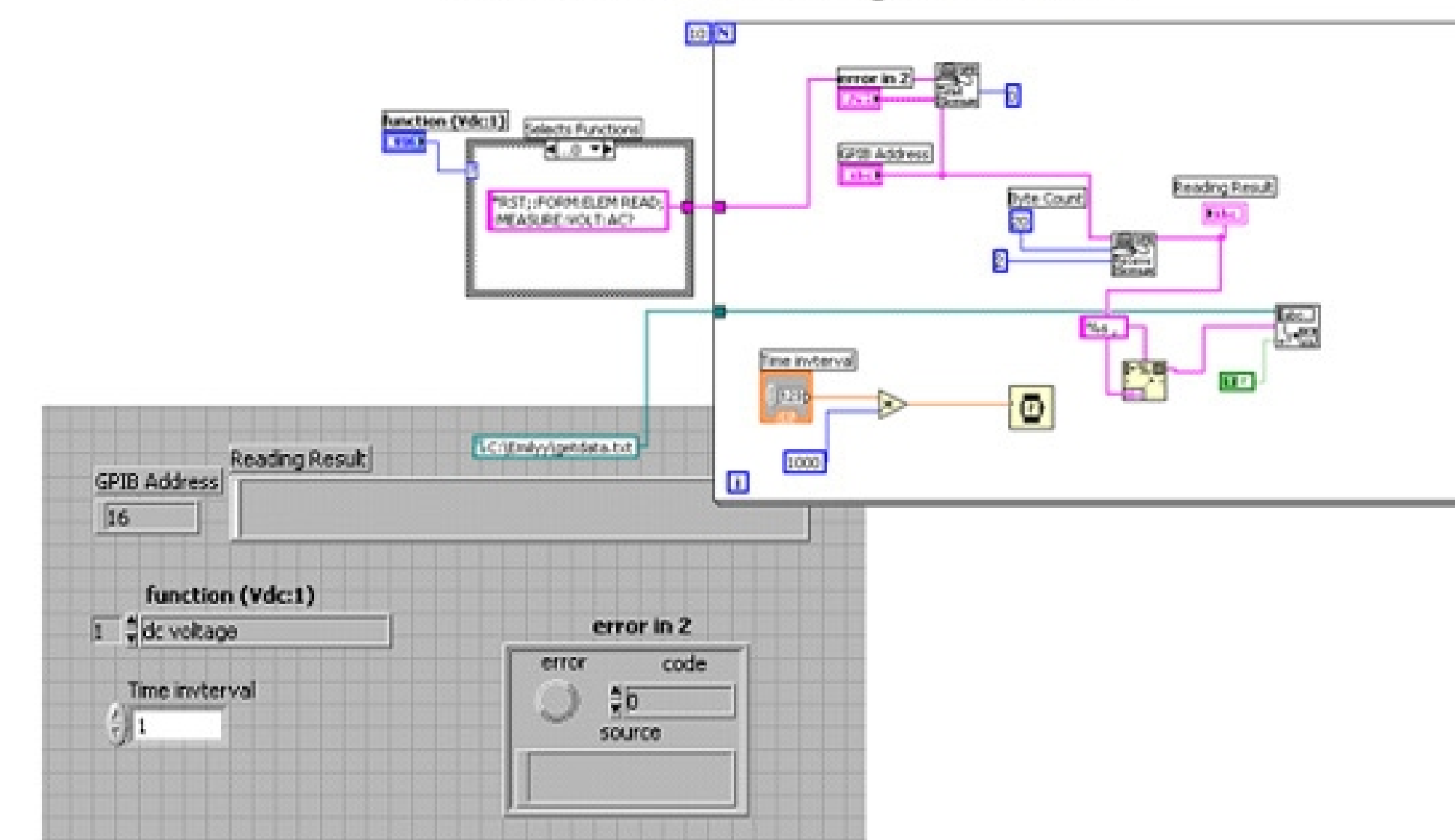


LabVIEW: Software Implementation

Using the software LabVIEW to implement and write a program to control the temperature of the device, LDT 5910B.



A program that involves taking the data from the Keithley 2000 Multimeter and writing it into a file.



Equation

The equation below will allow us to use the ratio of the intensity of anti-stokes and stokes to equate the temperature of each measurement.

$$\exp\left(-\frac{hc\omega_\mu}{k_B T}\right) = \frac{I_{AS}(\omega_\mu)/(\omega_i - \omega_\mu)^4}{I_S(\omega_\mu)/(\omega_i + \omega_\mu)^4}$$

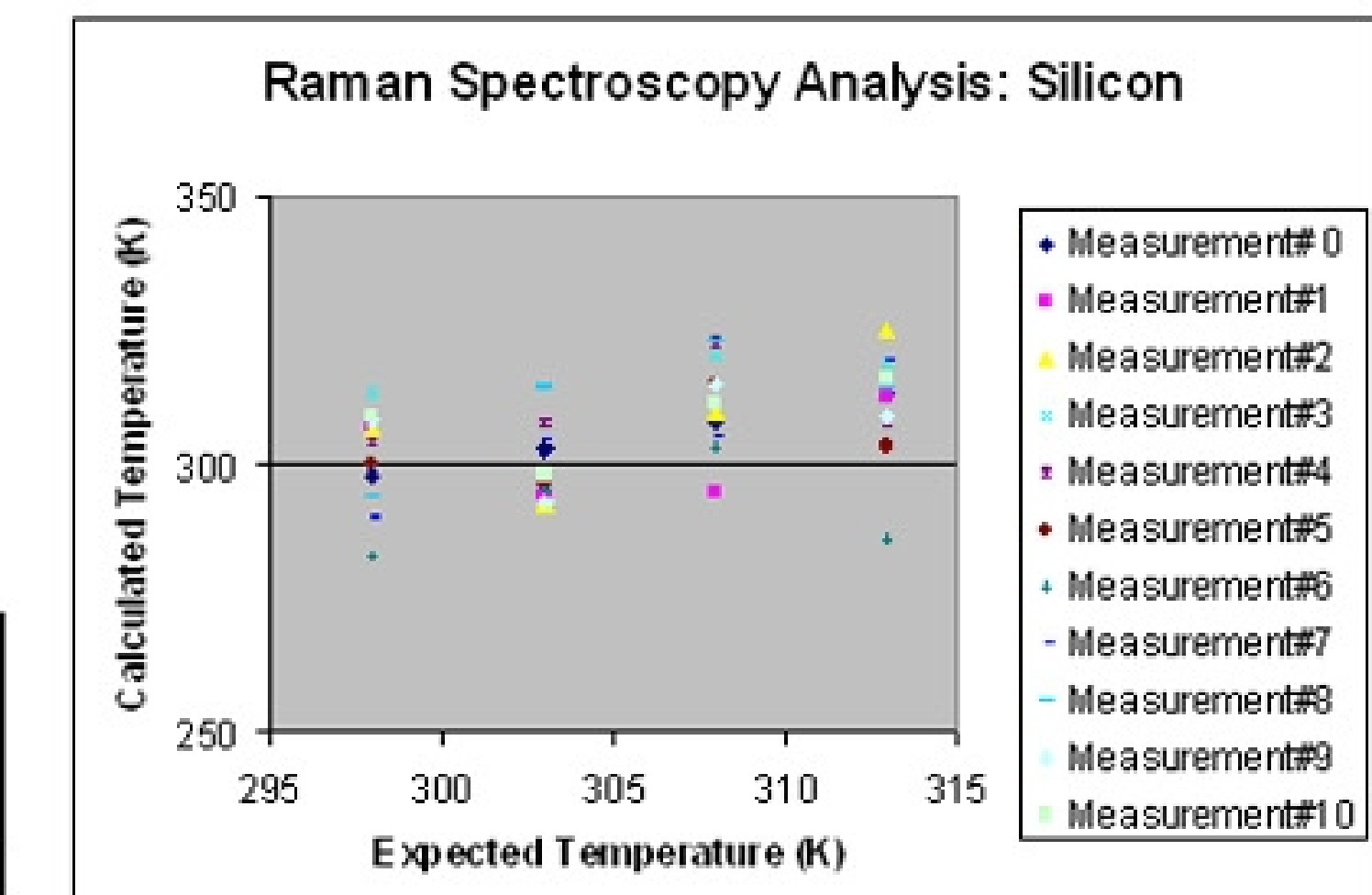
Symbol definitions:

- h = Planck's constant: $6.64 \cdot 10^{-34}$ J s
- c = speed of light: $3 \cdot 10^8$ (m/s)
- kB = Boltzmann constant: $1.38 \cdot 10^{-23}$ J K⁻¹
- T = Temperature of specimen in Kelvin
- wi = stimulating light frequency (cm⁻¹)
- wu = lattice vibration frequency (cm⁻¹)
- IAs = intensity of anti-Stokes (a.u.)
- Is = intensity of Stokes (a.u.)

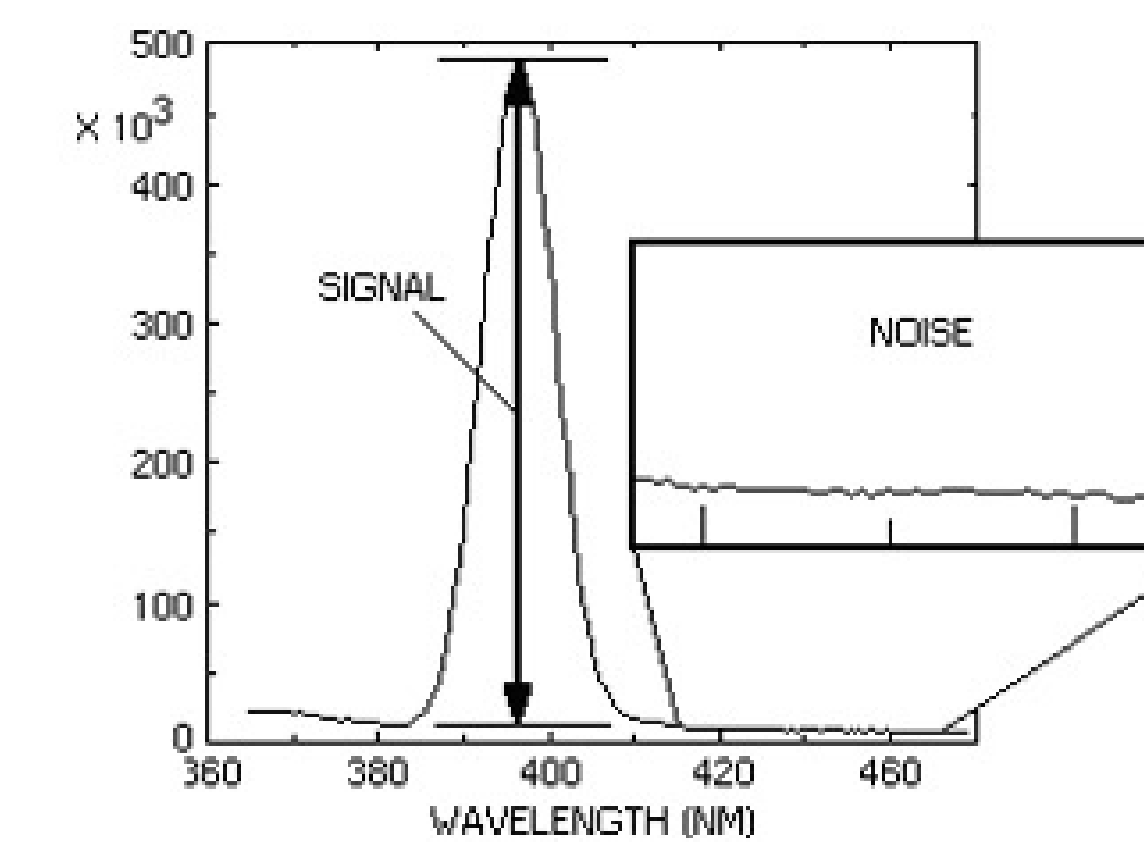
Observations Made During Analysis

- Light of room interfering with incident light
- Laser power intensity
- Switched from red laser to green laser for filter complications
- Thermal paste and copper to dissipate heat
- Background noise adding to peak intensity
- Not enough points to get accurate curve
- White light should be turned off
- Laser should be warmed up for some time

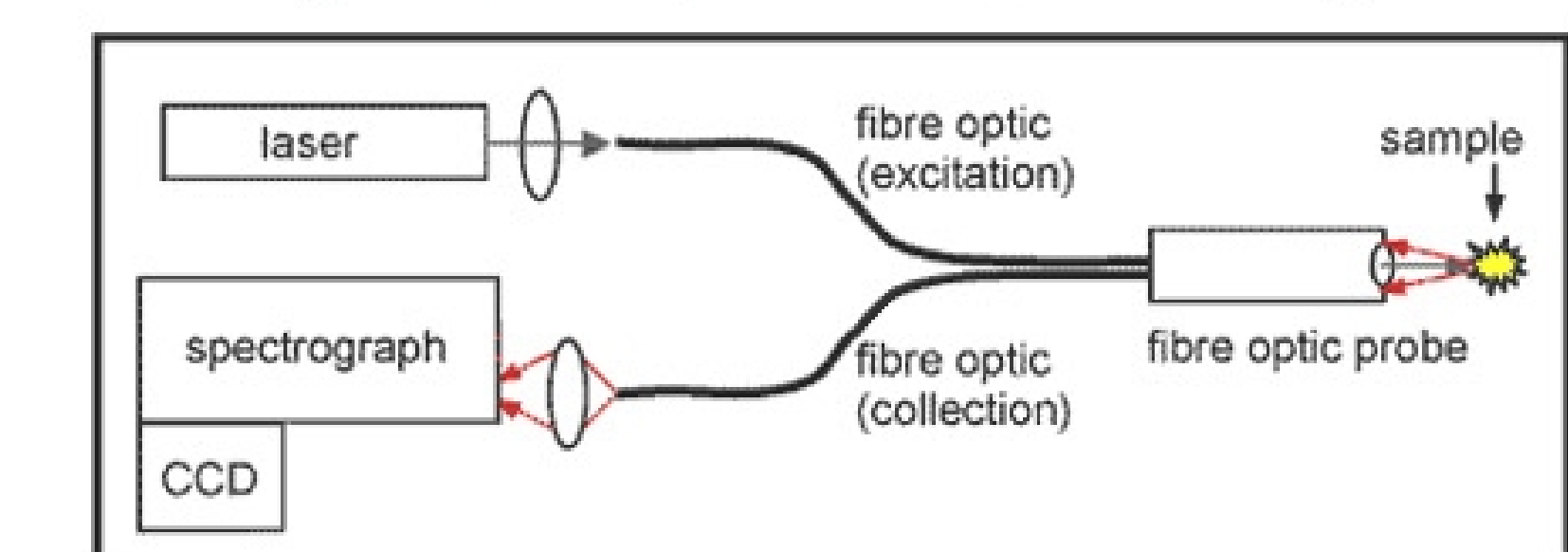
Graph



Number of Measurements	Temperature (K)	Maximum Error	Minimum Error
1	298	15.28	2.03
2	303	11.43	4.65
3	308	15.25	0.15
4	313	12.13	0.35



Physical Aspect of Raman Spec.



The basic components for Raman spectroscopy include a light source (normally a laser), collection optics to gather the Raman-scattered light, and a detection system. The detector is the heart of the system. It must be able to filter out stray light signals that may prevent the Raman peaks to be seen. Multiple dispersion stages are employed to reduce the amount of this stray radiation. A CCD camera is used to detect the Raman shifted light.

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 Advisor: Ali Shakouri and Javad Shabani

RoboBrain: A Test Platform for an Autonomous Robot

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