The result will be the state \(|n+1,m-1\) occurring from the state \(|n,m\). In accordance with the normalization rule, the respective matrix element, \(n+1\) and \(m\), we have to consider the following perturbation operator \(a+b+ba\), inducing scattering lines. We assume that, in terms of population, the number of excitation quanta on the excited levels, characterized by many levels of different structures. Then the spectrum of scattered EM radiation exhibits information about the structure and state of the system. Therefore Raman scattering is an informative probe for obtaining information about the system.

To understand the quantum systems, the quantum theory of light and matter is based on the existence of quanta of electromagnetic radiation, called photons. When a quantum of light interacts with a molecule, it can be absorbed, or part of the light can be scattered, with a change in wavelength. The change in wavelength observed in the scattered light is what is known as the Raman effect. The scattered light can be further analyzed to obtain information about the vibrational and rotational levels of the molecule. Raman scattering is an important tool in chemical and biological research.

There are two types of Raman scattering: Stokes and anti-Stokes. In the Stokes process, the scattered light has a lower frequency than the incident light, which is in line with the conservation of energy. In the anti-Stokes process, the scattered light has a higher frequency than the incident light. The quantum-mechanical description of Raman scattering involves the creation and annihilation of virtual particles, which are not present in the actual system but are considered to be present in a closed system.

Classical and quantum theory of Raman effect

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