

Raman atomic spectra indicate forced natural frequencies of an all-pervading electromagnetic medium

The hydrogen line spectrum shows Raman shifts

Johann Marinsek

marinsek@aon.at

Introduction – Raman scattering

When light waves pass through a transparent medium (for instance a crystal) the incident ray is scattered. In the scattered light one observes not only the frequency of the incident ray (Rayleigh scattering) but also sum and difference frequencies of the incident light frequency. Raman observed in addition to the Rayleigh frequency a number of much weaker lines that show a law like pattern. The shifting pattern of the satellite lines is independent of the frequency of the monochromatic incident ray but is the characteristic fingerprint of the scattering substance.

Thus if the incident ray has frequency ν_1 and is scattered for instance by diamond, the spectrum of the scattered ray consists of a line of frequency ν_1 and some shifted lines of frequencies $\nu_1 - \Delta\nu_{\alpha C}$, $\nu_1 - \Delta\nu_{\beta C}$... (Stoke lines or red-shift)

and $\nu_1 + \Delta\nu_{\alpha C}$, $\nu_1 + \Delta\nu_{\beta C}$... (anti-Stoke lines or blue-shift) where C denotes the scattering substance carbon C (diamond) and α , β , γ , ... denote the shifted lines.

For another frequency, say ν_2 the shifting pattern would be:

ν_2 , $\nu_1 - \Delta\nu_{\alpha C}$, $\nu_2 - \Delta\nu_{\beta C}$... and $\nu_1 + \Delta\nu_{\alpha C}$, $\nu_2 + \Delta\nu_{\beta C}$... $\nu_2 - \Delta\nu_{\beta C}$...

and $\nu_2 + \Delta\nu_{\alpha C}$, $\nu_2 + \Delta\nu_{\beta C}$...

The shifts $\Delta\nu_{\alpha C}$, $\Delta\nu_{\beta C}$, ... are the same as before, independent of the frequency of the incident light beam.

These shifts or differences in frequency are not vibration frequencies of the scattering crystal.

The scattering crystal is coupled with the all-pervading electromagnetic medium (EM medium) whose vibrations we perceive as light.

The Rayleigh frequency represents a natural frequency of the crystal, which oscillation causes a forced vibration of the EM medium. Frequencies of the forced vibrations form the Raman spectrum.

The Raman scattering technique is used to diagnose the internal structure of molecules and crystals.

The hydrogen line spectrum shows Raman shifts

The hydrogen line spectrum in the visible region contains some series of lines that are Raman shifted. The regular pattern of the shifted frequencies is obviously expressed in the well-known phenomenical Ritz-Rydberg formula for the hydrogen frequencies: $\nu = R_f (1/n^2 - 1/m^2)$, for any $n = 1, 2, 3, \dots$, $m = n + 1$ and goes from $n + 1, n + 2, n + 3, \dots$ to ∞ . ν_∞ is the limit frequency. For $n = 1$ we get the Lyman series, for $n = 2$ the Balmer series, for $n = 3$ the Paschen series, for $n = 4$ the Brackett series and for $n = 5$ the Pfund series.

R_f is the Rydberg frequency $R_f = 3,29 \cdot 10^{15}$ Hz. The term $R_f (1/m^2)$ expresses the shifts from the limit frequency.

The table shows the Lyman-, Balmer- and Paschen series for ν/R_f :

Lyman	ν/R_f	Shift $\Delta\nu$	Difference frequency; music
L_α	$(1 - 1/4)$	- 1/4	
L_β	$(1 - 1/9)$	- 1/9	$L_\beta - L_\alpha = H_\alpha$
L_γ	$(1 - 1/16)$	- 1/16	$L_\gamma - L_\beta = Pa_\alpha$
L_δ	$(1 - 1/25)$	- 1/25	$L_\gamma(f'')/L_\alpha(fis''') = 15/16$ (1/2 tone)
L_ϵ	$(1 - 1/36)$	- 1/36
L_ζ	$(1 - 1/49)$	- 1/49	
L_∞	$(1 - 0)$	0	

Balmer			
H_α	$(1/4 - 1/9)$	-1/9	H_α (gis')/ H_α (fis'') = 5/9 (7th)
H_β	$(1/4 - 1/16)$	-1/16	H_β (cis'')/ H_α (fis'') = 3/4 (4th)
H_γ	$(1/4 - 1/25)$	- 1/25	
H_δ	$(1/4 - 1/36)$	- 1/36	H_δ (e'')/ H_α fis'') = 8/9 (1/1 tone)
H_ϵ	$(1/4 - 1/49)$	- 1/49	
H_∞	$(1/4 - 0)$	0	

Paschen			
Pa_α	$(1/9 - 1/16)$	- 1/16	
Pa_β	$(1/9 - 1/25)$	- 1/25	
Pa_γ	$(1/9 - 1/36)$	- 1/36	
Pa_δ	$(1/9 - 1/49)$	- 1/49	

When transposed, the Lyman and Balmer series correspond to tones in music. See[Couso] for details.

In terms of the Bohr model for hydrogen, anti-Stoke lines (Raman blue shift) are not explainable.

Extreme ultraviolet spectrum of hydrogen explained as Raman shift

In 1991 it was possible to measure the extreme ultraviolet spectrum of hydrogen in the range of 80-650 10^{-10} m.

Lucas & Lucas [Lucas] discovered that the spectra of the extreme ultraviolet obey series like for visible light. The formulas for frequencies have Rydberg structure but instead of integer (principal quantum) numbers $n = 1, 2, 3, \dots$ in the first term $1/n^2$: $1/1^2, 1/2^2, 1/3^2, \dots$ there is an odd number: $1/(1/6)^2, 1/(1/5)^2, \dots$

$$\nu = R_f (1/(1/6)^2 - 1/(1/5)^2) - c/\lambda_c,$$

$$\nu = R_f (1/(1/5)^2 - 1/(1/4)^2) - c/\lambda_c,$$

$$\nu = R_f (1/(1/3)^2 - 1/(4)^2) - c/\lambda_c,,$$

$$\nu = R_f (1/(1/3)^2 - 1/(3)^2) - c/\lambda_c, \text{ and so forth.}$$

In this connection the only important feature of these formulas is that they represent a difference of two frequency terms. The resulting difference „tone“ can be interpreted due to a coupled oscillation where the first term represents the eigenfrequency of the atom and the second the resonance frequencies of the transmitting medium of the waves.

The extreme ultraviolet spectrum is not explainable in terms of the Bohr model because the principal quantum numbers n of quantum theory are integers. Here, the formulas show odd numbers.

Alkali metal spectra

The frequency formulas for alkali metals are the same as for hydrogen, only the Rydberg constant varies. Alkali metal spectra are found to obey Raman shift patterns like for hydrogen. The shifts of the satellite frequencies are therefore interpreted like for the Raman effect as eigenfrequencies of a transmitting EM medium.

X ray spectra can be interpreted as Raman shifting of incident ray

A second track to investigate the eigenfrequencies of the atomic cluster was begun by *Moseley*. The results obtained for *The High Frequency Spectra of the Elements* indicate that the square root of frequency is a linear function of the atomic number (and therefore partially a linear function of the number of the hydrogen constituents of the element). The L series of the spectra contain five lines for instance.

Moseley observed in 1913 that the line spectrum of elements due to incident X rays could be described in the analogous way to the series describing the hydrogen spectrum.

For every element there are K, L and M-lines where K, L, M denote the shells for the principal quantum numbers $n = 1$, $n = 2$, $n = 3$, respectively. The frequencies of the K_{α} -, L_{α} - and M_{α} -lines can be expressed by the empirical formulas

$$\nu (K_{\alpha}) = R_f (Z - X_K) (1/1^2 - 1/2^2)$$

$$\nu (L_{\alpha}) = R_f (Z - X_L) (1/2^2 - 1/3^2)$$

$$\nu (M_{\alpha}) = R_f (Z - X_M) (1/3^2 - 1/4^2)$$

where Z is the atomic number of the element and X_K , X_L , X_M are empirical constants.

The X ray spectra can be interpreted as follows: An incident X ray causes an excitation of the atom. The atom is coupled with an EM medium that works as a transmitter. The Raman-like frequencies shifts that we observe are the eigenfrequencies of that medium.

Hydrogen spectra indicate some features of the atom

Does the hydrogen spectrum indicate some features of the atomic structure? Indeed, physicists observed patterns or series of spectral lines of hydrogen.

The spacing between adjacent lines shows a decrease with decreasing wavelength until it converges at a limit. For the lines in the visible region, Balmer found a law-like pattern. In 1890 Rydberg found an empirical formula that describes the series of all wavelengths known at that time.

$$\text{Rydberg formula: } 1/\lambda = R_H (1/n^2 - 1/m^2),$$

where $\lambda =$ the wavelength, $R_H = 10973731.55 \text{ cm}^{-1}$ is the Rydberg constant for hydrogen and n, m are integers.

For the Balmer series in the visible region the formula is as follows:

$$1/\lambda = R_H (1/4 - 1/m^2), \quad m = 3, 4, 5, \dots$$

Because the velocity of light is: $\lambda \nu = c$ (ν being the frequency), we can rewrite the formula for frequencies: $\nu = \nu_H | 1/4 - 1/m^2 |$,

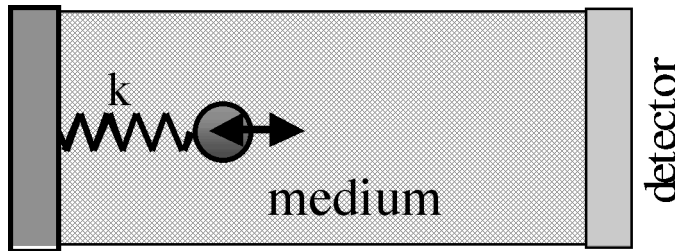
where ν_H is the hydrogen Rydberg frequency $3.289 \cdot 10^{15} \text{ sec}^{-1}$

So, every spectral line represents also a frequency of a specific vibration.

The Rydberg formula $\nu = \nu_H \left| 1/n^2 - 1/m^2 \right|$ represents a forced vibration

Formulas for frequencies for forced vibrations have the same structure as the formula for hydrogen spectra: $\nu = \nu_H \left| 1/n^2 - 1/m^2 \right|$.

In order to explain this feature we begin with a simple damped oscillation.



Damped oscillation: spring or stiffness constant k ,

natural frequency $\omega_0^2 = k/m$

damping force bv , $v \dots$ velocity.

Reduced frequency $\omega = \sqrt{\omega_0^2 - (b/2m)^2}$

$\omega \sim \omega_0 (1 - (b/2m)^2 / 2\omega_0^2) = \omega_0 (1 - b^2/8mk)$

The result is that for an eigenfrequency ω_0 of the oscillator, the frequency due to damping is

$\omega = \omega_0 (1 - b^2/8mk)$.

If the medium is an elastic lattice then this lattice has many eigenfrequencies or natural frequencies. If even the oscillator has many degrees of freedom and therefore many eigenfrequencies too, a detector would measure series of frequencies. Series A correspond to eigenfrequency A of the oscillator. In such a manner we obtain series A, B, ... of spectral lines.

Now we replace the oscillating mass by the oscillator atom and the medium by an EM medium that is the carrier for EM waves. Say a certain mode of oscillation of the atom has the natural frequency ν_{B0} (in the case of hydrogen, B may stand for Balmer). The detector would measure the forced oscillations frequencies of the electromagnetic lattice which are represented by the formula $\nu_B = \nu_{B0}(K_B - 1/m^2) \dots$ where K_B is a constant and $m = 1, 2, 3, \dots$

To summarize: We can interpret all Rydberg-type frequencies formulas

$$\nu = \nu_{\text{Atom}} \left| 1/n^2 - 1/m^2 \right|$$

as frequencies of a forced vibration of two coupled oscillators: the first term represents the eigenfrequencies of the excited specific atom.

The second term represents the resonance frequencies of the transmitting EM medium. The difference frequency (the difference „tone“) is the produced frequency of the EM transmitter that we observe as a spectral line. The fact that we have for instance about 1000 Fe lines indicates that the EM transmitter has many degrees of freedom. That is the case when the transmitting medium is thought as a crystal-like lattice.

Faraday, Kerr and Ehrenhaft observed some electromagnetic effects of light. This implies that the building blocks of this medium must be of electro-magnetic nature if the medium is discretely structured.

I assume that the hydrogen atom is an oscillator. This atomic oscillator is made up of permanent elementary ring magnets.

I assume that H exists in two varieties, namely ortho-H and para-H. Both varieties have many degrees of freedom and therefore many vibration modes with the corresponding eigenfrequencies.

The atoms are coupled with the all-pervading electromagnetic medium which vibrations we perceive as light. The formula $\nu = \nu_0 \left| \frac{1}{4} - \frac{1}{m^2} \right|$ for the Balmer series shows the forced vibrations of that medium.

The Balmer or Rydberg formulas are empirical formulas but they may exhibit some characteristic physical structures of the coupled oscillators. I speculate that doublet line spectra are caused by two different atomic structures, say by ortho- and paramagnetic structures.

References

[Raman] Raman, Nobel lecture, www.nobel.se

[bour] Bourbaki, G., Die klingenden Wasserstoffatome und die Quantenphysik. www.bourbaki.de Bourbaki rejects the concept of a photon, the energy formula $E = h\nu$ and the Rutherford/Bohr atomic model. For Bourbaki, spectral lines correspond to eigenfrequencies of an oscillator. For Bourbaki's atomic model you must study his paper.

[ariz] Arizona State University, Life science visualization Group
<http://askabiologist.asu.edu/pag>

[Couso] Couso, H., Musikalische Transkription der Wasserstoffspektren,
www.planetwave.de

[couso] Cousto, H. H₂ – Der Klang der Wasserstoffmoleküle. 1999
http://www.planetware.de/tune_in/wasserstoff.pdf Cousto showed that the hydrogen spectrum could be transcribed into music

[lucas] Lucas, J. and Lucas C.W. Jr., A Physical Model for Atoms and Nuclei — Part 3, Foundations of Science , February 2003, vol. 6, no 1.
<http://commonsensescience.org>