A Doppler-looking redshift observed in the labs; application to quasars

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Abstract. It is known since 1968 that the interaction of a pulse of light with matter redshifts the spectrum; the theory is clarified, to obtain the conditions for which, with incoherent light, one gets a redshift similar to a Doppler shift rather than Raman lines. The explanation of the appearance of the same absorption line with various z becomes trivial, requiring. only a static halo and a static magnetic field.

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1. Introduction

Some astrophysicists think that Doppler effect cannot explain all redshifts observed in astrophysics, but they were unable to find a serious alternative theory. It is strange that they did not notice that redshift are observed for a long time in the interaction of short pulses of light with matter [1, 2]. Yan et al. [3] gave a theory in a particular case, but the conditions in which a redshift appears rather than raman lines were not studied precisely. Making the meaning of "short pulse" clearer, we will apply the effect to usual incoherent light, in particular to the light coming from the stars.

2. The space coherence of the scattered light

It was tried to explain the redshift by a Raman scattering; the first reason for which it does not work is : the Raman scattering is incoherent, that is the scattered light is spread in all directions so that the images are blurred.

A laser is a source of space coherent light: a large source can emit for instance a nearly plane wave. Light amplifiers are able to increase the intensity of a light beam without any perturbation of the shape of the wave surfaces.

This property of light amplifiers is known in old optics: A small fraction of the Rayleigh diffusion is incoherent, producing, for instance the blue of the sky, but most Rayleigh diffusion is coherent, it produces a wave late of $\pi/2$ which interferes with the incident beam, giving the refraction.

In the theory of refraction, the refracting molecules perform two-photons virtual transitions, so that the initial state (say the ground state) is the same than the final state. What happens if the ground state is split by a perturbation ? If the perturbation is large, incoherent Raman appears, but for which perturbation do we have the turn from space coherence to incoherence ?

The origin of the incoherence of ordinary Raman scattering is the collisions; consider the molecules on a wave surface. In a classical scheme, they start to vibrate all in phase (in a quantum scheme, the computations of scattering are the same for all molecules); thus, all molecules emit wavelets similar to Huygens wavelets which construct a wave surface identical to the incident wave surface. These new waves may be Rayleigh, producing the refraction, or Raman. It seems that Raman scattering is coherent! It is not because the collisions stop the vibrations of the molecules; as the phase of the scattered wave is late of $\pi/2$ when the oscillator restarts, this phase depends on the instant of the collision. This is not important for Rayleigh scattering because the difference of phase between the incident and scattered waves does not depend on the time, but it makes the phases stochastic for Raman scattering, so that this scattering is incoherent.

Condition 1:

The Raman scattering is coherent if the duration of the light pulses is shorter than the time between two collisions in the gas.

However, in a gas, the dispersion generally changes the relative phases of the incident and scattered beams, so that the phases of the beams which are scattered on different wave surfaces are different: their interference is constructive if the medium is thin; if it is thick, it becomes destructive; the scattered intensity cannot be large ‡.

3. Interference of the incident and scattered beams

The second reason for which Raman scattering does not work is that the considered Raman transitions let appear new lines. Successive scatterings do not deplace the exciting line but diffuse it.

This interference is trivial in the appearance of refraction through the Rayleigh scattering. The definition of the frequency of a pulse is limited by the length of the pulse; how is it possible to distinguish two frequencies ? A simple computation shows that two sine functions may be added into a single one, with a good precision if their phaseshift during the pulse is lower enough than π. The final frequency is intermediate between the initial ones. Thus we get

Condition 2:

The appearance of Raman lines is replaced by a frequency shift if the half period of the beats between the incident and scattered waves is shorter than the length of the light pulses.

More precisely, the mathematical equivalence between two waves of different frequencies and a single wave of intermediate frequency leads to a vagueness of the

‡ The scattered intensity may be large on a cone if the beams are diffraction limited; we suppose here that the beams are wide

result; this vagueness is removed by the dispersion which destroys the two frequencies solution.

4. Application to incoherent light

Blackbody light is very incoherent, made of very short pulses. The light emitted by excited atoms, or blackbody light filtered by an absorbing gas is made of much longer pulses. Generally, these pulses are shorter than 10 nanoseconds, that is an interferometer does not give fringes if its difference of path is larger than 3 meters. Thus, we have some orders of magnitude in the scale of time between ordinary incoherent light and short pulses of light.

To fulfil condition 1 with incoherent light, the pressure of the gas must be very low; to fulfil condition 2, the distance of the Raman levels must be lower than 50 MHz, that is the molecule must have an hyperfine structure. Most molecules and atoms have an hyperfine structure; the exceptions are (roughly) simple molecules with an even number of electrons and atoms with a small number of electrons.

This effect, very similar to refraction is very important; the computation of an order of magnitude shows that if this effect produces the whole redshift of nebulae, the necessary amount of active molecules ($H_2^+, NH_2, OH, ...$) is of the order of 20 per cubic meter [4].

The energy lost by the redshift is transferred, in a parametric process, to the incoherent low energy (2.7K) radiation.

5. Application to the Lyα lines of quasars

The standard explanation of the appearance of the same line with various z requires thin clouds moving with very high speeds. We will suppose only the existence of a static high temperature halo over an extremely high temperature kernel, and the presence of a static magnetic field which falls to zero at 3 or 4 altitudes on the sight line [5].

The atoms which have no hyperfine structure where the field is nearly zero, acquire a Zeeman hyperfine structure elsewhere. When the light propagates near a zero of the field, the absorption lines are written into the spectrum. Then, between two zeros, the spectrum is redshifted, but the absorption is permanently displaced in the spectrum, so that the intensity of the spectrum decreases slightly, without an appearance of lines. Then, near the following zero, the lines are written in a new place.

6. Conclusion

It seems evident that the evolution of optical properties of light with the pressure of the gases may be extrapolated to very low pressures. It is not exact because the electromagnetic interactions between the molecules, in particular the collisions, play an important role, and these interactions decrease at pressures which are more commonly reached in the space than in the laboratory.

References

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