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Ab-initio computation of Karlsson's constant.

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Abstract

Statistical calculations by K. G. Karlsson (Astron Astrophys. 239, 50, 1990), G. R. Burbidge and other authors, show that the redshifts Z of the spectral lines emitted by quasars and galaxies accumulate close to Z(m) = mK, where K = 0061 is the "Karlsson's constant" and m some integers. We demonstrate this formula and find exactly K and the allowed values of m, using only rules commonly used in laser spectroscopy, the hypothesis of low pressure atomic hydrogen in 1S state around these stars and the observation of an initially continuous spectrum of a very hot star.

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1. Introduction

The observed frequency ν of a spectral line of a quasar or a galaxy is lower than the laboratory frequency ν_0. Even if ν_0 is in the infrared or microwaves, the "redshift" Z is defined by $Z = (\nu_0 - \nu)/\nu_0$.

K. G. Karlsson [1], G. R. Burbidge [2] and other authors showed that the distribution of the observed redshifts along an axis of redshifts is not homogeneous: the redshifts accumulate around $Z(m) = mK$, where $K = 0.061$ is Karlsson's constant and m an integer 3, 4, 6, ... Up to now, this result is not explained.

The astrophysicists explain the interaction of light with very low pressure gas considering that the photon is a small particle unable to interact with several distant molecules. Thus, they use Monte-Carlo computations which, in despite of complicated hypothesis are not convincing. Here, we follow W. E. Lamb, et al. [3] and most laser spectroscopists for which the photon is a pseudo-particle introduced in quantum electrodynamics by the quantization of "normal modes" of the electromagnetic field which need to be selected by the experiment. Thus, all light matter interactions with a large number of identical molecules making a low pressure gas, are coherent.

2. Variation of the Impulsive Stimulated Raman Scattering (ISRS), according to the length of the light pulses.

ISRS is a well-known optical effect used, in particular to study matter in K. A. Nelson's laboratory in M. I. T. ; for a review, see, for instance [4].

ISRS results from the interference of an exciting light pulse with a Raman coherent scattering induced by the pulse. The result is a progressive frequency shift of light. To avoid a saturation of the Raman levels, several simultaneous ISRS may be combined, in accordance with thermodynamics, into a parametric effect. Thus several beams exchange energy, therefore are frequency shifted, in a medium which plays the role of a catalyst.

Neglecting the dispersion of polarisability, the ratio $(\nu_0 - \nu_1)/\nu_0$ of a frequency shift to the initial frequency ν_0, named redshift Z_{ν_0,ν_1} does not depend on ν_1.

The Raman coherent scattering requires conditions of coherence written by G. L. Lamb [5] as: *The length of the light pulses must be shorter than all involved time constants.* To fulfill this condition, ISRS is generally studied using femtosecond pulses. Is it possible to use the nanosecond pulses which make the usual time-incoherent light?

Suppose that the pulses used in an experiment are replaced by k times longer pulses. How do the ISRS frequency shift is weakened by the necessary increase by k of the time constants, assuming that the other parameters may remain constant?

- To multiply the collisional time by k, the pressure, thus ISRS, must be decreased by the factor k.

- Addition of the Raman field to the exciting exciting field is the addition of two fields of different frequencies and equal initial phase. Before the appearance of beats, the main Fourier component has an intermediate frequency, in proportion of the amplitudes. The other components cancel by interferences. To Increase the quadrupolar period by the factor k, the Raman frequency shift, thus ISRS must be divided by k.

- We have always a Stokes and an anti-Stokes scattering, whose results have opposite directions. Assuming thermal equilibrium, the difference of populations of the Raman levels, assumed weak, is proportional to the Raman frequency shift: The ISRS frequency shift is divided by k.

Thus, the order of magnitude of ISRS is reduced by a factor k^3, of the order of 10^{15} : an observation of ISRS easy in a laboratory with 10 fs laser pulses requires an astronomical path with incoherent light. The parametric effect includes always a contribution of the thermal radiation, which redshifts light.

3. Propagation of light emitted by an extremely hot source in relatively cold atomic hydrogen.

The condition of coherence requires a quadrupolar resonance frequency lower than 1 GHz. The 1420 MHz frequency in the atomic ground state of H is too high. The 178 MHz in state $2S_{1/2}$, 59 Mhz in $2P_{1/2}$ and 24 MHz in $2P_{3/2}$ are convenient. In more excited levels, the quadrupolar resonance frequencies are too low for a large ISRS.

Assume that a very hot source, emitting a continuous spectrum in the UV-X region is surrounded by a region of low pressure hydrogen at a temperature of the order of 4 000 K, so that hydrogen is atomic, in its ground state.

Assume that the pressure of hydrogen decreases with the distance from the source, and that all distances involved are much larger than the size of the source, so that the source may be considered as a point, and a region interacts with a single light beam

Close to the source, the pressure is too large for an ISRS, the Lyman spectrum is absorbed, written into light.

At a larger distance, atoms excited by the Lyman alpha (Ly_α) absorption produce a redshift, so that the absorption occurs in a moving region of the spectrum: the new absorption lines are very broad and weak, invisible (Phase A).

Where the initially written Ly_β line gets the Ly_α frequency, the gas is not excited to the states of principal quantum number $n = 2$, the redshift stops, all lines of the gas, in particular all Lyman lines are visibly absorbed (Phase B).

The result is that two full spectra of H are well absorbed, one at the regular frequencies, the other with the redshift which puts the Ly_β to the Ly_α.

During phase B, it remains a weak redshift, by more excited atoms, or by their decay to n=2 states, so that the large redshift (phase A) restarts, and so on.

Space is divided into regions which redshift light, separated by regions which do not redshift. The experimental redshift shows that the total redshift corresponds generally to a final stop of the redshifts while an absorbed line has the Ly_α frequency (phase B).

The final, observed redshift is generally close to $bZ_{\alpha,\beta} + cZ_{\alpha,\gamma}$, where b and c are non-negative integers and $Z_{\alpha,\beta}$ (resp.$Z_{\alpha,\gamma}$) is the redshift which transforms the Ly_β (resp. Ly_γ) frequency into the Ly_α frequency.

$Z_{(\beta,\alpha)} = (\nu_\beta - \nu_\alpha)/\nu_\alpha = [(1 - 1/32 - (1 - 1/22)]/(1 - 1/22)] \approx 5/27 \approx 0.1852 \approx 3 * 0.0617;$ (1)

$Z_{(\gamma,\alpha)} = (\nu_\gamma - \nu_\alpha)/\nu_\alpha$ =[(1-1/42 -(1-1/22)]/(1-1/22)] = 1/4 = 0,25 = 4*0.0625. (2)

The redshifts are roughly product of $Z_0 = 0.062 \approx K$ by an integer q sum of integers 3 and 4. There is an overlap of lines, so we build a tree whose branches may merge. Certain values of q are remarkable, eg $q = 10 = 3 + 3 + 4 = 3 + 4 + 3 = 4 + 3 + 3$ corresponds to an intense line, thus a large probability of an observed redshift..

4. Conclusion.

The most likely redshifts of light produced along a path through very low pressure atomic hydrogen are sums of redshifts given by formula 1 and 2. It is remarkable that the statistics on redshifts by Karlsson, Burbidge and others allowed to find the value 0.061 of Karlsson's constant, equal, taking the precision into account, to the 0.0617 and 0.0625 theoretical values.

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