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Propagation of electromagnetic waves in space plasma. Applications.

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Abstract.
Parametric light-matter interactions are defined as transient processes in which the initial and final states of the matter are identical; the exchanges of energy are not quantified, and there is no minimum threshold of energy required to couple the transfer. The most common parametric interaction is refraction. Other parametric effects usually require microwave or laser sources. Coherent Raman Effect on Incoherent Light (CREIL), is a parametric effect that shifts frequencies without any blurring of the images or altering the order of the spectra of ordinary light. CREIL operates in gases having quadrupolar resonances in the megahertz range. CREIL is easily confused with Doppler effects. The propagation of light in low pressure cosmic gases involves a complex combination of absorptions and CREIL frequency shifts. The propagation of light in the extended photosphere of extremely hot objects is also complex because Lyman excitations of atomic hydrogen induce CREIL in hyperfine resonance states in the first excited quantum levels. A bistability emerges which chains Lyman absorption patterns through a coincidence of lines from each pattern allowed at one redshift into line patterns that coincide at other redshifts. This is not a coincidence of whole spectral patterns, but of discrete lines (for instance the coincidence of a redshifted Ly beta on the Ly alpha of the gas). This chaining is reflected in the apparent harmonic distribution of quasars.

Current star theory predicts very bright accreting neutron stars. These should be small, very hot objects surrounded by contaminated atomic hydrogen. CREIL predicts spectra for these stars that have the complexity and the characteristics found in the spectra of the quasars. The intrinsic redshifting in the extended photosphere of quasars as defined by CREIL events drastically reduces both the size and distance to quasars, and clearly identifies the missing neutron stars as quasar-like objects. A full and proper interpretation of quasar spectra does not require jets, dark matter, a variation of the fine structure constant, or an early synthesis of iron.

The coincidence of harmonic peaks and the prediction of neutron stars is a valid proof that, in despite of a lack of precision of the present computations of the redshifts provided by the CREIL, this effect has applications in astrophysics.

CREIL is useful in explaining other astrophysical problems, such as redshifting proportional to the path of light through the corona of the Sun. CREIL radiation transfers may explain the blueshifting of radio signals from the Pioneer 10 and 11 probes.

Key words. Redshifts, quasars.

1. Introduction.

A pulse of light causes a dynamically polarisation in matter. If the matter returns to the initial state after the transition of the pulse, the light-matter interaction is define as "parametric". The transient exchanges of energy are not usually quantified and, as the polarisation involves all identical molecules, if the number of identical molecules is large enough, the interaction is space-coherent, generating well defined wave surfaces. The simplest parametric effect is refraction, which is an example of a space-coherent light-matter interaction that occurs at even the lowest detectable intensities.

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If two objects of different temperatures are brought into contact, the warmer of the two objects is cooled and the cooler object is warmed. Since there is a Planck temperature associated with optical modes, a similar increase of entropy results from a parametric effect. This provides a “contact” between the light beams, allow a transfer of energy. The matter is unchanged, playing the role of a catalyst. The heated modes are blueshifted, the cooled modes are redshifted. This parametric effect is called CREIL (Coherent Raman Effect on Incoherent Light) if it applies to ordinary incoherent light. If lasers are used to stimulate these parametric effects, the process is called ISRS (Impulsive Stimulated Raman Scattering) [1]. ISRS and CREIL obey the same theory, but a very large difference in the controlling parameters, (the length and the peak power of the pulses) requires very different properties of the catalyst. To prevent a perturbation of the molecules during the parametric transfer, the pulses must be ultrashort, that is “shorter than all relevant time constants”(Lamb 1971).

ISRS works with dense matter having infrared quadrupolar resonances, and the frequency shifts depend on the large peak intensity of the light pulses, CREIL requires a low pressure gas having resonances in the megaherz range and does not depend on the intensity of the light. Consequently, while the observation of CREIL in a lab would require a very long and expansive multi-path cell, ISRS is easily observed.

The first subsection of section 2 summarises the theoretical generation and the properties of the CREIL, more precisely developed in previous papers (Moret-Bailly 1998a, 1998b, 2001).

The second part of this section compares the properties of the CREIL with the properties of its avatar, Impulsive Stimulated Raman Scattering (ISRS) (Giordmaine et al. 1968, Yan et al. 1985, Weiner et al. 1990, Dougherty et al. 1992).

Section 3 develops the result of a previous paper (Moret-Bailly 2003) indicating that the CREIL introduces a bistability during the propagation of the high flux of light radiated by an extremely hot source into low pressure atomic hydrogen.

Section 4 shows that this bistability produces a multiplication of absorption lines with the periodicity observed in the Lyman forest: This is established theoretically without the introduction of any new parameters.

Section 5 describes applications to the interpretation of observations. The most specific are:

- Subsection 5.1 applies the theoretical results obtained in section 4 to a very bright object surrounded by a contaminated cloud of hydrogen, an accreting neutron star. This very complicated spectrum has properties found in certain types of quasar spectra, solving both the question of the origin and nature of these quasars and the lack of observation of accreting neutron stars predicted by current stellar theory. These stars should be easily detectable, but have not been observed.

- Subsection 5.4 is an application of the CREIL to solar plasma, explaining the broadening of lines in the corona (Wilson-Bappu effect), and the anomalous blueshift of the radio transmissions of the Pioneer 10 and 11 space probes.

2. A Summary of the coherent Raman scatterings of light pulses.

The interactions of the dynamic polarisations at two frequencies may produce a Raman scattering, or, if the conditions for a parametric interactions are fulfilled, CREIL and ISRS. Therefore, it is useful to characterise CREIL and ISRS as a pair of simultaneous, virtual, opposite Raman transitions. This allows a comparative study of spectroscopic properties.

2.1. Conditions for a coherent scattering.

Refraction results from coherent scattering of the light without a change of frequency (Rayleigh scattering). Is it possible to obtain a similar coherent effect which also results in a change of frequency (Raman scattering)? Consider these examples:

In Rayleigh scattering, a difference in phase of $\pi/2$ exists between the exciting monochromatic beam, and the same beam scattered by molecules. Since the frequencies are equal, this difference of phase is constant, and not changed by collisions. Therefore the scattered and the incidental beams remain both time- and- space-coherent after collisions, interfering with each other to produce refraction. These collisions introduce only small perturbations, which are the source of Rayleigh incoherent scattering observed in sunlight.

If the scattered light has a different frequency, the difference in phase increases linearly with time. Since each collision restarts the scatterings, they randomise the phase shift, introducing an incoherence between the light scattered by different molecules. To prevent this incoherence, a coherent effect requires light pulses that are shorter than the collisional moment (the mean time between two molecular collisions).

Another example is the interference between two laser beams (or of the beams of a Michelson interferometer with a moving mirror) producing beat frequencies. If the duration of the observation is short, or if short pulses are used,

[1] Although these names and acronyms are a little misleading, they are preserved for historical reasons.

the beats are not detectable and a spectrometer then sees a single, intermediate aliased frequency. An elementary computation shows that the obtained frequency is in proportion to the amplitudes of the mixed beams.

Under both conditions, the light pulses are shorter than the collisional moment, and shorter than the period of the beats (the period of the Raman resonance), these pulses are therefore “ultrashort pulses” as defined by G. L. Lamb as “shorter than all relevant relaxation times”(Lamb 1971).

Refraction is a parametric process in which the dynamical polarisation by light perturbs the initial stationary state of the matter with the virtual excited state, which would be reached by an absorption. The “bending” of this polarisation requires an absorption of energy when the intensity of the pulse of light increases, and the energy of polarisation is returned to the pulse when its intensity decreases. Thus the matter returns to its stationary state after the pulse.

Replacing a Rayleigh scattering by a Raman scattering would leave an excitation of the matter which is forbidden by the necessity to return to a stationary state at the end of the parametric process. Therefore, it is necessary to combine the Raman process with a simultaneous opposite Raman process which de-excites the matter. The four (virtual) photon effect which is obtained is called “Impulsive Stimulated Raman Scattering” (ISRS) if it is generated by ultrashort laser pulses and “Coherent Raman Effects on Incoherent Light” (CREIL) if it is generated by the pulses of incoherent light. The “hot modes” are defined as the modes of electromagnetic waves whose relative Planck’s temperature is high, and, conversely the “cold modes” are the thermodynamically cooler waves.

CREIL (or ISRS) is a parametric interaction inside a set of pulsed electromagnetic modes, which increases the entropy by a transfer of energy from the hot modes to the cold modes, and a corresponding red (resp. blue) shift of the hot (resp. cold) modes. This interaction requires as a “catalyst” matter in which the light transition pulses are shorter than the kinetic collisional rate, and also shorter than the periods of quadrupolar resonances. Since this is a coherent effect, CREIL (or ISRS) does not blur the images.

Very often the beam temperatures are quite different, so that CREIL and ISRS are generally limited by the optical properties of the gas. It is worth noting Doppler effects due to the thermal or turbulent speed of the molecules is usually negligible with respect to the Raman frequency.

2.2. Differences between ISRS and CREIL.

Although ISRS and CREIL are fundamentally identical, and operate by the same theory, the orders of magnitude differences in both the peak powers and the lengths of the light pulses justifies the new name for CREIL.

ISRS radiation transfers involve powerful laser in femtosecond pulses. High peak energy is required to provide their detection, and, simultaneously, a larger ISRS effect : The energy of these pulses causes nonlinearities during the process. Thus in ISRS, the scattered amplitude is roughly proportional to the square of the exciting amplitude and the resulting frequency shifts depends upon the intensities of the lasers.

In contrast, in CREIL, the effective length of the radiation pulse is a few nanoseconds. The scattered wave amplitude is proportional to the amplitude of the exciting beam, therefore the frequency shifts are not dependent upon the source amplitude. Neglecting the dispersion of polarization, the relative frequency shifts $\Delta\nu/\nu$ do not depend on the incident frequencies ν . This makes it easy to confuse the increments of CREIL frequency shifts with Doppler shifts.

In both ISRS and CREIL, the quadrupolar resonance period must be longer than the length of the light pulses. This resonance is found in the infrared frequency range for ISRS, however it is in the megaherz range for CREIL. The low energy corresponding to these much lower frequencies is a third reason for the small CREIL frequency shift in a short path.

Since the mean time between molecular collisions must be longer than the length of the light pulses, the CREIL works only in low pressure gases. ISRS may be demonstrated in dense matter, causing frequency shifts are many magnitudes greater than CREIL frequency shifts in a given path. In a laboratory-sized experiments, ISRS is readily observed. Although the CREIL frequency shifts are too small to observe in laboratory environments, the process is additive over any distance: A space-based demonstration unwittingly has already been conducted (see section 5.4).

ISRS experiments generally use two lasers, but coherent frequency shifts can occur with a single femtosecond laser, the cold source being the thermal radiation. These shifts induce difficult experimental problems in fibre optics.

3. Propagation of Light in Atomic Hydrogen.

3.1. Propagation at relatively low temperatures.

Suppose that the radiation of a very hot object propagates in neutral, atomic hydrogen in its ground state 1S. At a temperature of 10 000 K, hydrogen is nearly in this state.

In their ground state, the neutral atoms have the well known 1420 MHz quadrupolar resonance, the excitation period of which is too short to allow a CREIL. The resonances corresponding to the quadrupole allowed transitions (ΔF = 1) that have the following frequencies 178 MHz in the $2S_{1/2}$ spin state, 59 MHz in $2P_{1/2}$ spin state, and 24 MHz in $2P_{3/2}$ are low enough to allow CREIL, and high enough to produce a strong CREIL effect. With each increase in principal quantum number, the Lyman absorption and the quadrupolar resonance frequencies decrease rapidly, so the CREIL effects are usually only active in the second and third quantum numbers.

In the first approximation of the gas not thermally excited, CREIL mechanism occurs only after a Lyman α absorption. Assume that the propagation of the light along a path L produces a frequency shift $\Delta\nu$ of the Lyman line, the displacement of the shift being much greater than the width of the line. (This shift occurs only when the atoms are pumped by Lyman absorptions, to low values of the final quantum number n.) The resulting redshift is proportional to the column density (number per unit of area) of excited atoms. Assuming that the decay time of the excited states is constant, the energy absorbed over $\Delta\nu$ has a well defined value that is proportional to $\Delta\nu$ and to the absorbed intensity. Thus, a constant intensity I_c is normally subtracted from the spectrum. This subtraction occurs if weak enough spectral lines have been previously written into the spectrum. This subtraction of a constant intensity increases the contrast of this spectrum. On the other hand, the absorptions which occur during the redshift cause wide, weak, unobservable lines.

The prior assumption, of the frequency shift $\Delta\nu$, fails if I_c is greater than the incident intensity, that is if the absorption of the energy available in a line width is unable to produce a redshift greater than the Lyα line width. In this case, after a short path of the light in the gas, it is no longer possible to achieve Lyman pumping, and there is a termination of this redshifting mode, and an ordinary absorption process starts. All lines, in particular the lines of possible impurities in the medium are written into the spectrum by this process. The contribution to CREIL by other Lyman absorptions does little to alter the previous description. For instance, it may be necessary to have a full Lyman beta absorption to cause a succinct disappearance of the redshift; but this does not extend to higher quantum numbers because the efficiency of the CREIL decreases.

To summarise, the bistability of the interaction induces two types of propagation: If the intensity is greater than I_c, the light is redshifted so that no spectral lines are visibly written into the spectrum. If the intensity is less than I_c, there is very little redshifting, and all spectral lines of the gas are visibly written into the spectrum.

3.2. Propagation in excited atomic hydrogen.

Consider now the heating of hydrogen by the absorption. If the temperature becomes high enough to thermally pump atoms into the first excited states, the heating increases the redshifting power of the gas, allowing a pumping by the higher intensity lines available in the regions of the light spectrum not previously absorbed; this induces an even greater heating: assuming that this heating is not large enough to de-populate the states 2S and 2P, a new contribution to the previously described bistability appears.

If the temperature becomes high enough to de-populate the 2S and 2P states, the redshift decreases, therefore the absorption by a given volume of gas decreases. Thus, it is very difficult to heat the gas by absorption of light over the temperature which starts to de-populate the $n = 2$ states.

Therefore, reaching this de-population requires a large light intensity. This large intensity pumps all lines strongly up to a large ionisation: either hydrogen is ionised, or it is in low excitation states if it is neutral.

4. Multiplication of the Spectral Lines by a Propagation in Atomic, Homogeneous Hydrogen.

To avoid confusions, define a *light-line* (with respect to a *light-spectrum*) as a line of either absorption or emission, written into the spectrum prior to this analytical sequence. This light-spectrum is subject to gravitational, Doppler, and CREIL frequency shifting. Define the *gas-lines* as the fixed frequency lines, either absorption or emission, that the gas is able to write into a traversing light beam.

First, assuming that the intensity of the light is greater than I_c, the frequencies of the light are shifting while absorptions occur, so that the light-lines written are wide and weak, essentially invisible. Next, assume now that an absorption light-line was previously written, for which the remaining intensity is lower than I_c; if this absorption light-line is redshifted to superimpose on a strong Lyman absorption gas-line, after its remaining intensity is fully absorbed by the Lyman absorption, the redshifting appears to stop. The whole gas-spectrum may now be written into the light-spectrum. The coincidence of the redshifted Lyman β (resp. Lyman γ) light-line with the Lyman α gas-line writes the Lyman pattern into the light-spectrum. The initial and just-written Lyman patterns differ by the shift of frequencies $\nu_{(\beta\,\mathrm{resp.}\,\gamma)} - \nu_\alpha$ between the α and $\beta(resp.\gamma)$ lines. As in the standard computations, the lines are considered as Lyman α , and the frequency shift is relative to the Lyman α frequency:

$z_{(\beta \mathrm{resp.}\gamma,\alpha)} = \frac{\nu_{(\beta,\mathrm{resp.}\gamma)}-\nu_\alpha}{\nu_\alpha} \approx \frac{1-1/(3^2 \mathrm{resp.} 4^2)-(1-1/(2^2)}{1-1/2^2}$

$z_{(\beta,\alpha)} \approx 5/27 \approx 0.1852 \approx 3 * 0.0617;$

$z_{(\gamma,\alpha)} = 1/4 = 0.025 = 4 * 0.0625.$

Similar to $z_{(\gamma,\beta)} \approx 7/108 \approx 0.065$. Notice that the resulting redshifts appear, within a good approximation, as the products of $z_b = 0.062$ and an integer q.

The intensities of the Lyman lines are decreasing functions of the final principal quantum number n, so that the inscription of a pattern is better for $q = 3$ than for $q = 4$ and *a fortiori* for $q = 1$.

Iterating, the coincidences of the shifted line frequencies with the Lyman β or α frequencies build a "tree", final values of q being sums of the basic values 4, 3 and 1. Each step being characterised by the value of q, a generation of successive lines is characterised by successive values of $q : q_1, q_2 ...$ As the final redshift is $q_F * z_b = (q_1 + q_2 + ...) * z_b$, the addition $q_F = q_1 + q_2 + ...$ is both a symbolic representation of the successive elementary processes, and the result of these processes.

The metaphor "tree", is imprecise because "branches" of the tree may be "stacked" by coincidences of frequencies. A remarkable coincidence happens for $q = 10$, this number is obtained by the effective coincidences deduced from an overlapping sequence of Lyman lines corresponding to the symbolic addition:

10=3+3+4=3+4+3=4+3+3=3+3+3+1=...

$q = 10$ is so remarkable that $z_f = 10z_b = 0.62$ may seem experimentally a value of z more fundamental than z_b.

In these computations, the levels for a value of the principal quantum number n greater than 4 are neglected, for the simple reason that the corresponding transitions are too weak.

It is worth emphasising that while the coincidence of an absorption light-line with a Lyman gas-line stops the redshifting, the gas will write emission or absorption lines into the spectrum as its excitation allows.

It is also worth noting that the coincidence of a Lyman gas-line with an emission light-line increases the redshift, so that it decreases the absorptions: the coincidence of an emission light-line with a Lyman gas-line seems to induce emission light-lines, so that the previous description certainly applies to the emission lines as well.

5. Applications of the CREIL to Astrophysics.

CREIL must be evaluated in the context of astrophysics because it is a simple effect deduced from normal spectroscopy. It is a general scientific concept that a simple theory is preferable if it provides a more succinct explanation than competing theories. The reader is invited to compare the complexity of the models, the number of new theories, and the number of parameters required to explain the following observations, using standard theory, and contrast this model with CREIL interpretations.

5.1. Propagation of the light in the halo of a hot, heavy object.

Consider the enigma of the accreting neutron star. Although these stars are predicted to be highly visible by generally reliable stellar evolution theory, they have never been seen. The criteria used in a search for the spectrum of this object are: 1) It is extremely hot (1 000 000 K); 2) very small, 3) very dense and 4) surrounded by a cloud of contaminated hydrogen. A natural consequence is that the density of the gas decreases with increasing radial distance to the surface. It can also be assumed that the temperature decreases as well, and that the surface of the object radiates a continuous spectrum similar to the spectrum of a blackbody having a lower temperature.

To keep this model as simple as possible assume that this halo is made entirely of atomic hydrogen, so that we do not have to take into account negligible CREIL redshifts due to impurities. To demonstrate an accreting neutron star has the spectrum of a quasar, it is useful to use the words describing the properties of the quasar spectra:

The object is surrounded first by a thin ($<$ 100 metres) sheet of gas, similar to as the atmosphere of a white dwarf (in which the pressure slightly broadens the spectral lines, but prevents a CREIL). Remark that the orders of magnitude of the paths for which the types of interactions change vary very much, from metres close to the object to astronomical units far of it.

Again, to simplify the model, the building of the light-spectrum as the light moves from the object will be described considering first independently the variations of density and temperature, although these variables are bound.

A) Variations of temperature.

a) The very hot ($T > 10^6$ K) surface of the object emits, from the infrared to gamma rays, a spectrum which is roughly the spectrum of a blackbody at a lower temperature. The temperature of the gas close to the object is higher than the Planck temperature of the light emitted by the surface. Emission lines are written, just as they are close to the Sun. Then the temperatures become nearly equal, at least at some wavelengths, there is no exchange of energy, no lines. Finally, all lines are absorbed.

b) Very close to the surface, the atoms are mostly ionised.

B) Variations of pressure.

Three effects change the visibility, width and the shape of the lines:

a) The collisions widen the lines, but we are interested by gases the pressures of which are lower than 10^4 Pa, for which this effect may be neglected.

b) If the ratio $r =$ absorption/(redshifting power) is large, the lines allowed by the selection rules are saturated, but saturation does not mean everywhere that the intensity decreases to zero: it means that the temperature of the light reaches the temperature of the gas. If this result is reached not only at the high spectral end of the strong gas-lines, but at the "feet" of these lines as well, the intensity becomes a constant value for a notable variation of frequency, so that the line gets the shape of a trough, or a hat. For a lower absorption, the lines are simply broadened.

C)Combination of temperature and pressure variations in the generation of CREIL.

A notable CREIL effect requires the existence of atomic hydrogen in states $n = 2$, and of a low enough pressure.

a) Close to the surface, a too high pressure forbids CREIL, so that the emission lines are not shifted, they are strong, slightly broadened by the pressure. While the allowed lines are broadened by their saturation, the forbidden emission lines and the lines of impurities remain sharp, so that they are used to define the standard redshift of the quasars.

b) Then, neutral atomic hydrogen, partly thermally excited in the states $n = 2$ appears. The forbidding of CREIL by pressure disappears, a permanent CREIL shifts the lines which are not written visibly into the spectrum. Therefore there are NO observed "Lyman forest" lines within a redshift of about $z = 0.5$ to the source. Contrast this with the standard interpretation: Photo-ionisation of the entire interstellar medium at extremely vast distance from the quasar. (Rauch 1999).

c) Then, the thermal excitation of hydrogen disappears, the states $n = 2$ of hydrogen are only populated by the Lyman absorption, the periodicities described in section 4 appear. At the beginning, remaining collisions handicap the CREIL, so that the ratio r is large and the lines are saturated, broad. With a decrease of the temperature and the density of the gas, the lines become sharper, building the Lyman forest with the periodicity described in 4 and observed in the spectra of the quasars (Burbidge 1968 , Burbidge & Hewitt 1990, Tifft 1976, 1996, Bell 2002, Bell & Comeau 2003). Writing lines requires long paths through the gas, while redshifting corresponds to short paths. Therefore, there is a large probability that the building of the Lyman forest stops at a large distance by disappearance of hydrogen, while a line is being written. This is why there is a high probability that the observed redshifts z are multiples of 0.062 (Arp 2004).

This description fails partly if the object radiates a strong radio field. This field may be produced by, or produce an ionisation of the gas in the pressure range where broad lines normally occur; without neutral hydrogen, there is no CREIL functionality: The emission, then the absorption of a line occur at the same place in the light-spectrum and the set of broad lines does not appear.

The ability of CREIL to resolve this cosmic periodic function, which has no valid function in a uniformly expanding universe, is a sterling accomplishment.

The spectroscopy of the region close to the surface is very difficult because all relevant distances are short. For instance, the emission of weak lines may be larger slightly out of the lines-of-sight to the kernel than on these lines.

As CREIL depends on the tensors of polarisability, the relative frequency shifts $\Delta\nu/\nu$ depend slightly of ν , so that, after a CREIL shift, the relative distances of lines making fine structures are not the same than after a Doppler shift. With the standard theory, it is necessary to suppose that the fine structure constant is variable (Webb et al. 1999).

If we suppose that the total redshift is large, and that the object is bright, the CREIL transfers much energy to the thermal light which may become hot not only in the line of sight to the kernel, but on all rays which cross the halo. Thus it seems that the object is surrounded by hot dust.

Our hypothesis are very simple, they correspond, for instance to the accreting neutron stars, and we obtain most features of the complicated spectrum of a quasar. As a neutron star is old, it has produced simply the observed iron. Postulating that the missing accreting neutron stars have not been observed because they are identified as quasar, solves not only the problem of the complexity of the spectrum of the quasars without extraordinary hypothesis, it resolves both the nature and the origin of the quasars and the absence of observation of accreting neutron stars (Treves & Colpi 1991, Popov et al. 2003).

As the quasars are not very far, they are not huge objects. The CREIL introduces the intrinsic redshifts needed by Arp 2001 to avoid putting the Earth in a lot of planes defined by close galaxies and distant quasars, that is at the apparent center of the Universe.

This interpretation of such a complicated spectrum from simple hypothesis and standard spectroscopy cannot result from a coincidence. Previous computations of the order of magnitude of the CREIL showed that it seemed necessary to take CREIL into account in astrophysics, but we knew that this order of magnitude was not accurate. The present demonstration that at least some of the quasars are accreting neutron stars, is a strong demonstration of the effects of the CREIL in astrophysics.

5.2. Quasars and very red galaxies.

A path of their light through the halo of the quasars may produce a large redshift of galaxies. Therefore there is a statistical over abundance of very red objects (VROs) in close proximity to quasars (Hall et al. 2001, Wold et al. 2003). Galaxies that contain quasars in their centres are often both severely reddened, and redshifted relative to other galaxies at the same apparent distance. This is why quasar galaxies appear to be so huge. They are average sized galaxies, as their morphologies tend to indicate (Boller 2003)

The thermal radiation of these galaxies, attributed to hot dust, is simply high because the CREIL is large.

5.3. The Wilson-Bappu effect.

In 1957, Wilson and Bappu discovered the width of the CaII K emission line is proportional to the absolute magnitude of certain classes of stars and can therefore be used to calculate distance. A similar method has been developed using the Mg II K emission line at 279.634 nm. Although a high degree of correlation exists between these methods across a fairly high range of luminosities (CC=0.9), it breaks down for very high flux stars, and breaks down completely in binary systems. Cardini et al. 2003 observes:

We observe that the corresponding correlation coefficient is fairly high in spite of the ~ 6*order of magnitude span in line luminosity. This is a remarkable result in itself, which should deserve proper study for its implications in the understanding of line broadening mechanisms in the chromospheres of stars. The distribution of binary stars in the Mg II K peak width vs. magnitude does not show any regular pattern. On the contrary, binary stars are closely correlated in Mg II K peak magnitude vs. magnitude. Such a strong correlation is also found for normal stars but normal stars are systematically fainter in the MgII K line by a factor of* ~ 10 *compared to binary stars.*

Just as with the Tully-Fisher relationship, the width and magnitude of these peaks and the confusing correlations are fairly simple to model using a CREIL process: The bigger and therefore brighter the star, the more redshifting that occurs near the radius of the chromosphere, broadening the peaks. When two stars are close to each other, the intense flux from each star creates an increase of the intrinsic redshift throughout the elementally enriched space between the pair, greatly increasing both the width and the magnitude of the metal emission lines.

5.4. Observations of the CREIL in the solar system.

The variation of frequency shifts on the solar disk shows three origins for these shifts: Doppler, gravitational, and a shifting proportional to the path of the light through the corona. CREIL effects easily explains the corona line shifting and the resulting Wilson-Bappu effect (Cardini et al. 2003) in stellar spectra without resorting to extremely high velocity gas flows.

Another result of CREIL is evident in a crucial experiment : Radio signals were sent from the Earth to Pioneer 10 and 11, at a well stabilised carrier frequency close to 2.11 GHz, and the Pioneers returned a signal after a multiplication of the carrier frequency by 240/221. The blueshift which remains after a standard elimination of the known frequency shifts (Doppler, gravitation) is interpreted as produced by an “anomalous acceleration” (Anderson et al. 2002). The CREIL allows to preserve celestial mechanics : Assume that the solar plasma between these Pioneer probes and the Earth contains molecules possessing resonances in the megaherz range (either or for instance Lyman pumped atomic hydrogen). These molecules transfer energy from the solar radiation not only to the thermal radiation but to the radio signals too : Planck’s temperature of the radio signals is higher than 2.7K to allow a detection, but much lower than the temperature of the solar radiation. Crucial experiments could be performed on a future probe: the blueshift should decrease if the carrier only were emitted, the low remaining modulation being produced by the interference of the carrier with the thermal noise. Studying the variations of the blueshift as a function of the frequency of modulation, a spectroscopy of the quadrupolar resonances in the solar plasma could be tried.

6. Conclusion

The displacement of quasars spectra by intrinsic CREIL redshifting has prevented the proper assessment of their fundamental nature. We have demonstrated how the spectrum of quasars contains the signature of the missing accreting neutron stars.

A previously proposed new model of the quasar (Moret-Bailly 2003) is not conceptually wrong, but more complicated and less precise and complete than this one. Our present model uses only the consequences of standard spectroscopy and matches many phenomenon as observe in nature. This is especially true when compared with the standard cosmological model. Specifically:

- Since much of the redshift is intrinsic, quasars are not as distant as current estimates. Consequently, when the Hubble law is applied to the remaining redshifted lines (Petitjean et al. 1996, Shull et al. 1996), they are much closer, less massive, and less brilliant than current theory dictates.

- The complexity of quasar spectra, including the shapes of the lines, is best explained by CREIL effects in a simple dirty hydrogen halo, as opposed to a sequence of baffling jets and sporadic clouds strained by dark matter (Tytler 1987).

- Radio-loud quasar spectra demonstrate strong absorptions close to the redshift of the emission lines, these lines are intrinsically redshifted into broad lines in radio-quiet quasars (Briggs et al. 1984, Anderson et al. 1987).

- In a Big Bang scenario, since the neutron stars [quasars] are not older than the local universe, no early generation of iron is needed to explain these spectra.

- The interstellar medium is much denser and much more homogeneous than has been calculated by using estimates based on the hydrogen density mapped calculated in the faces of quasers.

- Since CREIL depends on the polarisability of an active gas, the dispersion of this polarisability produces variations of the relative frequency shifts $\Delta\nu/\nu$ which distort the multiplets: there is no need to vary the fine structure constant(Webb et al. 1999), to achieve these effects.

- The most redshifted and bright objects, in particular the broad absorption line (BAL) quasars, emit a relatively hot thermal spectrum (Omont et al. 1997) synthetised by CREIL.

CREIL is necessary to understand the anomalous blueshifts of the radio emissions of the Pioneer space probes. Although the other applications of the CREIL may appear less specific, the CREIL is a powerful tool in understanding the propagation of the light in low pressure gases, and to understanding many other astronomical observations, in particular those for which Arp showed the necessity of “intrinsic redshifts”.

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