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Submitted on 1 Jan 1984

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Diamagnetic behaviour of xenon Rydberg states studied by the R.F. optogalvanic method

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(Reçu le 3 août 1983, accepté le 11 octobre 1983)

Résumé. — On étudie le comportement diamagnétique d'états de Rydberg nf du xénon au moyen d'une excitation par laser à colorant monomode et de la méthode de détection R.F. optogalvanique. Les niveaux sont suivis depuis leur position en champ nul, au travers des régimes de mélange diamagnétique des l puis des n, jusqu'à ce qu'ils atteignent la limite d'ionisation en champ nul \( ^2P_{3/2} \), où l'on observe le régime dit de « quasi Landau » puis jusqu'à environ 20 cm\(^{-1}\) au-delà de cette limite. On vérifie que les positions des raies dominantes sont en accord avec les résultats de calculs effectués sur un modèle hydrogénoïde et avec les prédictions d'une approximation semi-clas-sique.

Abstract. — The diamagnetic behaviour of xenon nf Rydberg states is studied using single-mode dye laser excitation and an R.F. optogalvanic detection method. The levels are followed from their zero-field positions, through the inter-l and inter-n diamagnetic mixing regimes, until they reach the zero-field \( ^2P_{3/2} \) ionization threshold, where the so-called « quasi Landau » regime is observed and up to 20 cm\(^{-1}\) above this threshold. The positions of the dominant lines are found to be in agreement with the results of hydrogenic calculations and with the predictions of a semi-classical approximation.

1. Introduction.

Many theoretical and experimental works have been devoted in the recent years to the problem of atoms submitted to a strong magnetic field. (A comprehensive review on this topic including numerous references has recently been published by Gay [1].) Let us specify that we shall consider a magnetic field as a strong one, if the Lorentz force applied to the outer electron of the studied element is at least of the same order of magnitude as the Coulomb force binding this electron to the core. With laboratory available field intensities, this condition will only be fulfilled by loosely-bound electrons, that is to say high n atomic energy levels. For such levels, the interaction between the atom and the magnetic field is dominated by the diamagnetic term of the Hamiltonian.

Since the early results of Garton and Tomkins [2], most of the experiments on atomic diamagnetism had been carried out on alkaline-earth elements. Main experimental advances were however realized in the recent years by Castro et al. [3, 4] on sodium and by Gay et al. [5-7] on caesium. These authors have shown the importance of performing high resolution experiments on highly hydrogenic Rydberg series, for comparison with theoretical predictions, generally limited to hydrogen-like species.

In this paper we want to show that rare gases and particularly xenon can offer interesting opportunities for studies of this type. We want furthermore to emphasize the use for the first time in this experimental field of the R.F. optogalvanic detection method. Advantages and drawbacks of this method applied to strong field experiments will be discussed.

2. Principle of the experiment.

Xenon atoms, contained in a cell, are excited by an R.F. discharge in their lower excited states which include the levels of the \( 5p^3 \) \( 5d \) configuration. From there, a monomode dye laser can excite levels of the \( nf \) series in the vicinity of the first ionization threshold. The cell is placed at the centre of an electromagnet providing fields up to 2.2 T. Either the laser wavelength \( \lambda \) or the magnetic field \( B \) may be varied. Laser induced transitions as \( \lambda \) or \( B \) is swept, are detected through variations of the anode current of the R.F. oscillator due to changes of the discharge impedance.
3. Experimental set up.

The laser is a commercial ring dye-laser, pumped by an argon-ion laser. Monomode emission is obtained by insertion in the cavity of a three plates birefringent filter and a 15 GHz air-spaced etalon, the transmission peak of which is locked to the laser mode. It provides several hundred milliwatts in the 540-620 nm wavelength range with a bandwidth of about 10 MHz. Wavelength scanning is obtained by varying the pressure inside the cavity. The laser is thus entirely placed in a leakproof chamber in which the pressure can be varied from 0.5 to 1.5 atmosphere, allowing 150 GHz readings without modehops. In spite of its heaviness, this system offers several advantages. It requires no sophisticated electronic device, except for a small correction of the birefringent filter position whose bandwidth is slightly smaller than the quoted 150 GHz. It provides furthermore a good insulation of the cavity from atmospheric dusts and vibrations, leading to a very stable and reliable behaviour of the laser. Wavelength calibration is achieved through the use of a 1 m grating monochromator to ± 0.1 A, further improvement of the accuracy is obtained by recording the absorption spectrum of molecular iodine [8]; an ultimate uncertainty of ± 10 mK is so obtained.

The detection of highly excited states is generally founded on an ionization process followed by ion detection. Spontaneous ionization can occur in the case of autoionizing levels. Electric field ionization is widely used in the case of atomic beam experiments, photoionization is also employed. In the case of vapour phase experiments, collisional ionization becomes an efficient process for those levels situated very close to the ionization threshold, allowing thermoionic [5-7] and optogalvanic detection to be used. Optogalvanic detection which applies to samples in which a discharge may be created, seems to be particularly suited to the study of rare gases, for which in case laser excitation of levels in the vicinity of the ionization thresholds may be done only from lower excited levels previously populated by a discharge. We have employed a variant of this method: namely R.F. optogalvanic detection method [9-11], in which the discharge is produced by an R.F. oscillator and the impedance variations of the discharge correlate to laser induced transitions between levels are monitored through changes in the rate of the oscillator. We used a lamp oscillator analogous to the one described by the authors of reference 11 working at a frequency of about 30 MHz, it is coupled to a 1 cm edge cubic cell, connected to a 100 ml reservoir, by means of two 5 mm diameter external electrodes stuck on opposite sides of the cube. A power consumption of 100 to 200 mW by the oscillator produces in the cell a very faint and stable discharge having the appearance of a 3 mm diameter sphere. The laser beam chopped at a frequency of about 2 kHz crosses the cell and the 2 kHz component of the voltage across the load resistor of the oscillator is detected by a lock-in amplifier. The strongest transitions lead to relative variations of about 10^{-2} of the total current of the oscillator, but variations down to 10^{-7} of this current may still be easily detected in this way.

An advantage may be immediately recognized to this type of detection: the fact that it does not require internal electrodes greatly facilitates the realization of cells, allowing the use of very small ones which are necessary when they are to be used in the narrow gap of an electromagnet.

The magnetic field is provided by an electromagnet with a 2 cm gap. The field may be varied up to 2.2 T and calibrated by proton magnetic resonance.

4. Experimental results.

4.1 Experiments in zero magnetic field. — The ground state of a xenon atom corresponds to a 5s^2 5p^6 configuration. All the levels in which we are interested here, belong to configurations obtained by excitation of one p electron to a nl state. They are then all built on the ^2P_{3/2} or ^2P_{1/2} states of the 5s^2 5p^5 ionic core and are respectively named, following the Racah coupling scheme, as nl(K) J or nl'(K) J states. K is the angular momentum obtained by coupling the total angular momentum 3/2 or 1/2 of the ionic core with the orbital momentum l of the external electron. The total angular momentum J being obtained by coupling K with the spin of the external electron. nl' series converge towards the upper (^2P_{1/2}) ionization threshold. As the fine structure of the ground state of the ionic core is large (about 10 000 cm^{-1}) most of the nl' members are autoionizing levels situated above the lower (^2P_{3/2}) ionization threshold. The nl series converge towards the ^2P_{3/2} ionization threshold, and may be perturbed by the lowest members of nl' series.

Three main reasons led to the choice of nf series in our experiments: their simple excitation scheme, the relatively high value (l = 3) of the orbital momentum of their external electron involving low quantum defect and the fact that these series might be essentially unperturbed, since the possible perturbers which are the members of np' or nm' series, are situated either below the 5p^5 4f configuration or above the ^2P_{3/2} ionization threshold. The zero-field experiments were partly carried out in order to verify these assumptions.

The most important aim of these zero-field experiments was however to demonstrate the ability of our detection method to provide reliable spectroscopic results for highly excited atoms, which, due to their large dimensions and high polarizabilities, are very sensitive to external perturbations. The existence of relatively high ion and electron densities in the heart of the discharge on one hand and the necessary use of gas pressures sufficient to provide a stable discharge on the other hand, may indeed be considered as the two major drawbacks of optogalvanic detection devices, as far as highly excited levels are concerned.
Pressure broadenings and shifts as well as Stark shifts of highly excited s and d states of xenon were extensively studied by Labastie et al. [12, 13] in an optogalvanic experiment very similar to ours, but with an experimental set up which allowed zero pressure and zero discharge intensity extrapolations. Such a procedure being not possible with our detection set up, we endeavoured to minimize as much as possible the spurious effects of relatively but necessarily imperfect experimental conditions, checking our results in comparison with those of reference 12 when possible.

Due to the mixing between $5p^5 6s$ and $5p^5 5d$ configurations, efficient excitation of $nf$ levels may be realized from $5s'(1/2) 0$ metastable or $5s'(1/2) 1$ resonance levels. The corresponding transitions are well known to give rise to strong optogalvanic signals [10]. This excitation scheme would however require a monomode dye laser working in the blue region of the spectrum (pumped by an U.V. ion laser) which we had not at hand and the use of which would have been less easy than for a classical rhodamine dye laser. The great sensitivity of R.F. optogalvanic detection allowed us to excite $nf$ levels from the levels of $5p^5 5d$ configuration, which are certainly much less populated than the levels of $5p^5 5s$ configuration, but are sufficiently long lived states to lead to excellent optogalvanic signals also. Among all the levels of the $5p^5 5d$ configuration, $5d(7/2) 3$ is the one which allows the best excitation of $nf$ levels. Most of the experiments described in this paper were however realized by excitation from $5d(1/2) 0$ level, the use of which permits only excitation of the $nf(j = 1)$ series in zero field and leads to a great simplification of the Zeeman effect in high field as it will appear further.

Pressures from 0.1 to 0.4 torr of 94 % isotopically enriched $^{136}$Xe were used for our zero-field experiments, though discharge stability considerations required the use of 0.4 torr filled cells for high field experiments. Under these conditions pressure broadening becomes obvious as $n$ increases, allowing however perfect observation of $f$ levels up to more than $n = 70$ when excited from $5d(7/2) 3$ level and about $n = 55$ when excited from $5d(1/2) 0$. As for the influence of the discharge, it was found that ($a$) the maximum signal amplitude was luckily obtained for the faintest discharge and ($b$), while the focusing of the laser into the brightest part of the discharge led indeed to the observation of slightly asymmetric line profiles, together with the appearance of parity forbidden transitions towards $ng$ levels with an amplitude ratio of about $5 \times 10^{-3}$ with regard to $nf$ excitation, the asymmetry and the parity forbidden transitions were spectacularly decreased when the laser was focused slightly aside in regions of the cell from which no visible light is emitted, but where excitation of $nf$ levels still gave rise to important optogalvanic signals. Under these conditions the members of the $nf(j = 1)$ series are observed with quantum defect value

$$\delta = 0.056 \pm 0.002,$$

no irregularities due to possible perturbations are detected and the value obtained for the $3P_{3/2}$ ionization threshold is

$$L = 97,834.24 \pm 0.02 \text{ cm}^{-1}.$$

Several determinations were made of $\delta$ and $L$ for various values of the pressure, their results were in agreement within experimental uncertainties.

Our $L$ value lies in good agreement with the value of Labastie et al. [12] $L = 97,834.26 \pm 0.01 \text{ cm}^{-1}$ (1). This makes us confident that R.F. optogalvanic detection, owing to its great sensitivity and to the very low values of the R.F. power used, allows the detection of highly excited members of the $nf$ series in conditions which enable us to perform a reliable study of their behaviour in strong magnetic field.

4.2 STRONG FIELD EXPERIMENTS. — When thinking about realizing xenon $nf$ series optogalvanic spectroscopy experiments in a strong magnetic field, two important questions immediately arise. The first one is : how will our detection device behave in a strong magnetic field ? The second is : will the theoretical treatments currently used (see Ref. 1), which are generally limited to the case of hydrogen or hydrogenic atoms, apply to the interpretation of our spectra ?

The answer to the first question is given by the experiment, in fact we did not encounter much difficulty in transferring our zero-field experimental device to a strong-field one. The cell is inserted in the gap of the electromagnet with the two electrodes placed in such a way that the electric oscillating field is parallel to the magnetic field $B$. The laser beam is sent perpendicularly to the magnetic field allowing $\sigma$ or $\pi$ polarizations to be used. Correct choice of the gas pressure and tuning of the oscillator allow stable discharges to be maintained for every value of the magnetic field and the detection system to work without spectacular decrease of sensitivity. It even seems to us that this detection device should continue to behave properly for higher values of the field. As it will be shown later, large magnetic field scannings may be performed without disturbing dramatically the discharge.

It is well known that, due to its non separability, the theoretical problem of an hydrogen or hydrogenic atom in a strong magnetic field is not yet resolved. A lot of approximate treatments have been developed allowing a partial interpretation of experimental results, they will not be repeated here since a complete bibliography on that subject is contained in reference 1. We shall only examine, as an answer to our second question, how our system satisfies the basic assumptions of the most commonly used of these approximate

(1) A value previously determined by us [10] was in slight disagreement with the value of reference 12. This value was obtained in an experiment using a much more intense discharge and we think that the observed discrepancy can be attributed to the consecutive perturbation of levels positions.
treatments. Simple considerations on the relative values of the different terms of the Hamiltonian will afterwards allow us to define the field of validity of the two treatments used for the interpretation of our experimental results.

The xenon atom (atomic mass of the isotope used was 136), is certainly a good candidate with regard to the negligibility of motional electric field, equivalent to the assumption of an infinite nucleus mass, as proven by the results obtained by Gay et al. [5] on caesium (atomic mass 133).

An analysis of the fine structure of the 5p\textsuperscript{n} n\textit{f} configurations shows that for \( n = 10 \) the spin doublet splitting is of the same order of magnitude as the Doppler effect of the recorded lines that is to say 500 MHz or 17 mK. As no levels with \( n < 30 \) are considered in our experiments, the rapid decrease of this spin doublet structure as \( n \) is increased ensures us for the total negligibility of spin orbit interaction.

The very low measured value of \( \delta \) is a proof of the quasi hydrogenic character of n\textit{f} series. For increasing \( n \) values, the very small energetic discrepancies (with regard to a purely hydrogenic behaviour), associated to such a quantum defect will in fact become rapidly negligible in comparison with the effect of the magnetic field. A total independence of the external electron from the ionic core influence would however require the negligibility of the coupling term between the core angular momentum and the orbital momentum of this electron. This term is responsible for the \( K \) structure of the n\textit{f} configurations which is equal to about 8 cm\textsuperscript{-1} for \( n = 10 \); assuming a \( n^{-3} \) variation for this structure [14] leads to values of respectively 270, 60 and 17 mK for \( n = 30, 50 \) and 75. Very small field values will then, at least beyond \( n \approx 50 \), completely decouple the angular momentum of the core from the orbital momentum of the \( f \) electron. This allows calculation of the Zeeman effect of n\textit{f} levels in a very simple way.

We note that the energetic region concerned in our experiments, which extends to about 100 cm\textsuperscript{-1} on both sides of the \( ^2\text{P}_{3/2} \) zerofield ionisation threshold, is free from any perturbing level belonging to series converging towards \( ^2\text{P}_{1/2} \) threshold.

Using the symmetric gauge, \( A = 1/2 \text{B}_d \cdot \text{r} \), to express the vector potential, the Hamiltonian \( H \) of the hydrogen atom in a magnetic field \( B \) may be written in cylindrical coordinates \((r, \theta, z)\):

\[
H = \frac{p^2}{2m} - \frac{eB}{2m} L_z + \frac{e^2 B^2}{8m} r^2 \sin^2 \theta - \frac{e^2}{4 \pi \varepsilon_0 r} H_z - \frac{e^2}{4 \pi \varepsilon_0 r} H_D - \frac{e^2}{4 \pi \varepsilon_0 r} H_C
\]

the mass of the nucleus is assumed to be infinite and the \( z \) axis to be directed along the field.

\( m \) and \( e \) are respectively the mass and the charge of the electron and \( L_z \), the \( z \) component of the angular momentum \( L = r_A \cdot \text{p} \).

The Zeeman or paramagnetic term \( H_D \), linear in field, is \( n \) independent. The diamagnetic term \( H_D \), quadratic in field varies like \( n^2 \) through the \( n^2 \) dependence of \( r \), the Coulomb term \( H_C \), varies like \( 1/n^2 \). For low \( n \) levels \( (5d(1/2) 0 \) and \( 5d(7/2) 3 \) levels of xenon atom, \( 5 ^2\text{P}_{1/2} \) and \( 5 ^2\text{P}_{3/2} \) levels of xenon ion for instance) and for usual values of the field, the diamagnetic term is negligible relative to the paramagnetic term. Such levels exhibit typical Zeeman behaviours. For high \( n \) levels, on the contrary, the diamagnetic term rapidly dominates the paramagnetic one, it may even become comparable to or greater than the Coulomb term itself, leading to a complete modificatio- 

\([15]\) in this paper we shall simply consider \( K \) as a label allowing to distinguish between the various wave-functions, though a complete definition of \( K \) has been recently provided by an exact analytical treatment of \( H_D \) in a given energy shell \((n)\) (see Ref. 15). This label \( K \) must not be confused with the angular momentum used in the Racah coupling scheme mentioned earlier and designated by the same character.
to the one obtained in a hydrogenic case to be reached at high field (energy of the levels varying linearly with $B^2$ and field independent wavefunctions).

From our experimental point of view (excitation from $5d(1/2)\ 0$ level one could fear that very intricate spectra should be obtained, since, for high $n$ values numerous $l$ values are involved and the spectra corresponding to the excitation of $m_l = 0, \pm 1, \pm 2, \pm 3$ diamagnetic levels are expected to merge, since, furthermore, the Zeeman splittings of the various levels have to be accounted for. Fortunately two important simplification factors occur. Firstly the comparison of computed line intensities shows that the lines corresponding to the excitation of $m_l = \pm 3$ levels should dominate the spectra. Secondly it is easy to verify that in $\sigma$ polarization the lines corresponding to transitions between $5d(1/2)\ 0$ level and $m_l = \pm 3$ diamagnetic levels do not undergo any Zeeman shift. Consequently the energies obtained for the levels from the positions of the dominant lines of the spectra may be directly compared to the results of $H_D$ diagonalization.

The spectra recorded for $n = 31$ level (3) and various $B$ values in the range 0-2 T are displayed on figure 2. From the wavenumbers of the lines indicated by arrows we have calculated the positions of corresponding energy levels, they are those corresponding to the stars on figure 1. The agreement between theory and experiment is obvious. For each field value of figure 1 the black star refers to the position of the more intense component in the corresponding spectra. It clearly allows us to follow the migration of the $l = 3, m_l = \pm 3$ dominant character among the wavefunctions from the one corresponding to the lowest level at low field to the one corresponding to the highest level for a field of 2 T.

Figure 3 displays a theoretical spectrum reconstituted from computed intensities and positions of lines for 1.715 T field value. The comparison with the experimental spectrum shows that the agreement between theory and experiment extends to fainter lines. The analysis of relative intensities of lines in the two spectra offers a test for the linearity of our optogalvanic detection device.

(3) We have not chosen a higher $n$ level, in spite of the fact that, as we have seen earlier, for $n = 31$ the decoupling of the angular momenta of the core and the external electron would probably not be utterly effective for the small values of the field. In fact in this case at low field values the collisional broadening of lines could have prevented the observation of level splitting and at high field values the effect of the diamagnetic term should have been greater than $2R/n^3$, which is contrary to the condition of validity of the approximation used. Another condition which had to be satisfied by the studied level, was the non appearance of any strong optogalvanic signal coming from transitions between other levels and hindering the detection of diamagnetic levels in the wavelength range of interest.

Of course such an approximate treatment becomes defective as soon as diamagnetic levels issued from adjacent zero field levels begin to interact and fails absolutely when the diamagnetic manifolds of different $n$ merge in the so called « inter $n$ mixing » regime. However the observed tendency to the domination of spectra by the lines corresponding to the excitation of levels prolonging the $m_l = \pm 3, K = 1$ levels persists and opens the way to the use of another approximation valid in the whole field of our experiments, as far as the interpretation of the dominant lines of the spectra only is concerned. This approximation, initially applied to the interpretation of the results of Garton and Tomkins [2] by Edmonds [16] and widely used since that time (see Ref. 15 for instance), is based on the fact that in cylindrical coordinates, if one neglects the movement of the electron in the $Oz$ direction along which the magnetic field is supposed to be directed, the problem of a hydrogenic atom in a strong magnetic field reduces to a separable two-dimensional problem, which may be solved by application of the W.K.B. method. Although such a model, which accounts only for the existence of one level for given $n$ and $|m_l|$ values instead of two multiplets of opposite parities, cannot pretend to allow a complete interpretation of the spectra, it is however very useful for two main reasons. Firstly, $|n, m_l = \pm 3, K = 1\rangle$ eigenfunctions describe electrons for which the movement is essentially localized near the $z = 0$
Experimental recordings of the transitions, in a polarization, between 5d(1/2) 0 level and the diamagnetic levels issued from 31 f(3/2) 1 level, for various magnetic field values. The arrows indicate the lines corresponding to \( m_\ell = \pm 3 \) levels.

Secondly, it appears that levels, with the same parity and same \( m_\ell \), but different \( n \), only interact weakly for highly hydrogenic excited states, [6] allowing us to follow experimentally « diabatic » levels, corresponding to a given \( n \) at low field values, across the various diamagnetic regimes, until they reach the ionization threshold and beyond this threshold. Two main features of the « quasi Landau » regime observed in the vicinity of the ionization threshold may be predicted through the use of this method, they are the \( n^3 B = \) constant behaviour of the levels for an energy \( E = 0 \) and the \( 3/2 \hbar \omega_c \), energetic spacing of the « quasi Landau » levels (\( \omega_c \) being cyclotron pulsation).

We have used this approximation to compute the positions of \( m_\ell = \pm 3 \) diamagnetic levels; hatched lines of figure 4 reproduce their behaviour for \( B \) values from 0 to 2 T and energy values between \(-50 \) and \(+30 \) cm\(^{-1}\). White stars on this figure correspond to experimental points obtained from spectra recorded while scanning \( B \) at a fixed energy value (i.e. at a fixed wavelength of the laser). Black stars correspond to experimental points obtained from spectra recorded at a fixed \( B \) value while scanning \( \lambda \). The two methods have their own advantages according to the region, in the \((E, B)\) plane, where the experiment has to be performed. They provide results which are in excellent agreement when they can be compared. The experimental results fairly agree with theoretical predictions particularly at low field values.

One can notice that experimental points are quoted on figure 4 corresponding to levels with \( n \) up to more than 70 which are not observed in zero field when exciting from 5d(1/2) 0 level. This is probably due to the fact that we limit our observation to lines corresponding to levels for which the spatial extension of the wavefunction is much smaller than for the zero field Rydberg level of same \( n \) and thus much less sensitive to collisional depopulation (owing to the localization of the electron near the \( z = 0 \) plane and to the confinement of its movement by the magnetic field).

In a paper of July 1982 [17] Feneuille, considering results obtained so far, conjectured that there might exist for such « diabatic » levels a scaling law relating the quantities \( n^2 E \) and \( n^3 B \), valid for the whole range of the magnetic field. Using the results of references 4 and 5 he derived a semi-empirical analytic expression for this scaling law. This conjecture was further supported on theoretical basis in a recent paper by Gallas et al. [18] who derived a scaling law very close to Feneuille’s. \( n^2 E \) versus \( n^3 B/B_c \) values from our experiments are plotted on figure 5 (\( B_c = 2.35 \times 10^5 \) T,

Fig. 3. — Comparison between the experimental (upper) and theoretical (lower) spectra, of the transition, in \( \sigma \) polarization, between 5d(1/2) 0 level and the diamagnetic levels issued from 31 f(3/2) 1 level at 1.715 T.
Theoretical energy (hatched lines) versus magnetic field $B$ from two dimensional semi-classical approximation for $m_s = \pm 3$ diamagnetic levels. The stars represent experimental points obtained from the positions of the dominant lines of the spectra. Being the critical field value) together with the curve representing Feneuille's analytical expression of the scaling law. As the parameters of this expression were fitted on the results of references 4 and 5 it provides indeed an indirect comparison of our results with these ones. Contrary to the case of W.K.B. approximation one can notice that the agreement is better at high field than at low field values.

On figure 6 a spectrum obtained by excitation from 5d$(7/2)$ 3 level in $\pi$ polarization at a fixed energy of $-0.09 \text{ cm}^{-1}$ that is to say very close to the ionization threshold is displayed. We did not use excitation from this level in our experiment, in spite of the fact that it is very effective, because it provides very intricate spectra due to the Zeeman effect. However in $\pi$ polarization and around the ionization threshold the Zeeman splittings only result in the observation of broader lines than the corresponding ones obtained from 5d$(1/2)$ 0 level. We show this spectrum because it provides a nice illustration of the correlative decrease of the background signal and increase of the heights of the edges, mentioned by Gay et al. [1, 15], associated with the diminution of the number of unresolved secondary lines, corresponding to various degrees of excitation along Oz, as the field is increased.

5. Conclusion.

We have demonstrated, in this experiment, that the system constituted by a xenon atom in a strong magnetic field allowed us to study the diamagnetic behaviour of highly excited Rydberg states. We have furthermore
demonstrated, by comparison of our results with the results of other experiments and with theoretical predictions, that R.F. optogalvanic detection method allowed to reliable spectroscopic data to be obtained in zero and strong magnetic fields.

Encouraged by these positive results, we are now working on the extension of our experiments to the study of the behaviour of autoionizing levels belonging to series converging towards the higher \( ^3P_{1/2} \) ionization threshold of xenon, in a strong magnetic field. We also intend to study the influence on the lowest autoionizing states (situatd just above the \( ^2P_{3/2} \) ionization threshold), of the modifications induced by the magnetic field into the continuum with which they interact, that is to say the interaction of an autoionizing level with a series of « quasi Landau » levels. In view of the results of this experiments, it appears that for xenon the lowest autoionizing levels are probably situated too high above the \( ^2P_{3/2} \) ionization threshold. Nevertheless we are very confident in the fact that the use of other rare gases will soon provide us with interesting experimental opportunities in that field.

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