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Leonard Sosnowski.

On the polarisation of the *Cd*-vapour fluorescence.[1] [2]

O polaryzacji fluorescencji pary kadmu. [3]

Streszczenie.

W celu wyjaśnienia charakteru reemisji wykrytej przez Kapuścińskiego w parze *Cd*, badano polaryzację fluorescencji pary *Cd* wzbudzanej światłem linjowo spolaryzowanem oraz niespolaryzowanem, obserwując w kierunku prostopadłym do kierunku naświetlania.

Jako źródła światła służyły iskry: kadmowa, cynkowa i glinowa. Polaryzację wykrywano zapomocą płytki Savarta połączonej z pryzmatem Wollastona użytym jako analizator. Kompensująca płytka kwarcowa pozwalała określać stopień polaryzacji z dokładnością do 1%. Stwierdzono, że pasma van der Lingena są spolaryzowane częściowo, zarówno przy wzbudzeniu światłem linjowo spolaryzowanem, jak i niespolaryzowanem, przyczem płaszczyzna częściowej polaryzacji jest wyznaczona przez kierunek wiązki wzbudzającej i kierunek obserwacji.

Przy wzbudzeniu światłem niespolaryzowanem stopień polaryzacji $P = 5^1/_2\%$, przy wzbudzeniu światłem spolaryzowanem $P = 11\%$, gdy obserwujemy w kierunku prostopadłym do wektora elektrycznego światła wzbudzającego i $P = 0\%$ przy obserwacji w kierunku wektora. W granicach temperatur od $560^0 C$ do $800^0 C$, co odpowiada zmianie ciśnienia nasyconej pary *Cd* od 40 do 1000 mm *Hg*, nie stwierdzono zmiany *P*.

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[1] L. Sosnowski, C. R. *195*, 224, 1932.

[2] Read at the VIth Meeting of the Polish Physical Society in Warsaw, September 1932.

[3] Praca referowana na VI Zjeździe Fizyków Polskich w Warszawie, we wrześniu 1932.

Jest to pierwszy dotychczas zaobserwowany wypadek polaryzacji w pasmach fluktuacyjnych.

Prążki reemisji są spolaryzowane w tym samym stopniu co i otaczające je pasma, co świadczy o wspólnym z niemi charakterze emisji i wyklucza możliwość tłumaczenia reemisji Rayleigh'owskiem rozproszeniem światła w parze *Cd*.

W pasmie fluorescencji widzialnej żadnych śladów polaryzacji nie wykryto.

Panu Profesorowi Dr. S. Pieńkowskiemu pragnę złożyć serdeczne podziękowania za powierzenie mi tego zagadnienia i liczne cenne rady i wskazówki.

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In close connection with the *Cd*-vapour band fluorescence is the characteristic effect, first observed by Kapuściński, of „reemission" [1]. If the exciting spark light has intense lines in the region of continous *Cd*-vapour absorption, then the fluorescence spectrum shows these lines as quite broad (to 50 Å), intense maxima on a background formed of bands. These bands, discovered by van der Lingen cover the region from 2260 Å to 3050 Å, having characteristic intensity fluctuations between 2450 and 3050 Å. Similar bands were observed, and their structure examined, by Jabłoński, in absorption [2].

One could suppose the lines of reemission are real maxima in bands, being the effect of intensity distribution in exciting light. The reemission can be treated also as a separate effect observed only together with band fluorescence. Landsberg and Mandelstam [3]) discovered similar phenomena in *Hg*-vapour and explained them as to be due to Rayleigh scattering in *Hg*-vapour. This could suggest such an explanation also for the effect of reemission. The authors explained its great intensity, considerably larger than scattering in gases, as the result of proximity of an absorption line. In order to investigate the

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[1]) W. Kapuściński, C.R. de Soc. Pol. de Phys. fasc. VIII, 1927, and Nature, *116*, 863, 1925.

[2]) A. Jabłoński, C. R. de Soc. Pol. de Phys., *III*, 175, 1928.

[3]) Landsberg u. Mandelstam, ZS. f. Phys., *72*, 130, 1931.

character of this „reemission", I observed the polarisation of *Cd* band fluorescence, excited by polarised and unpolarised light. In case the opinion given above should be right, a strong polarisation of the lines would be expected when observed perpendicularly to the direction of the exciting beam.

The experimental method was changed during the work. The double refraction in Wollaston prism used in the beginning to detect the polarisation, was replaced by the interference method of Savart

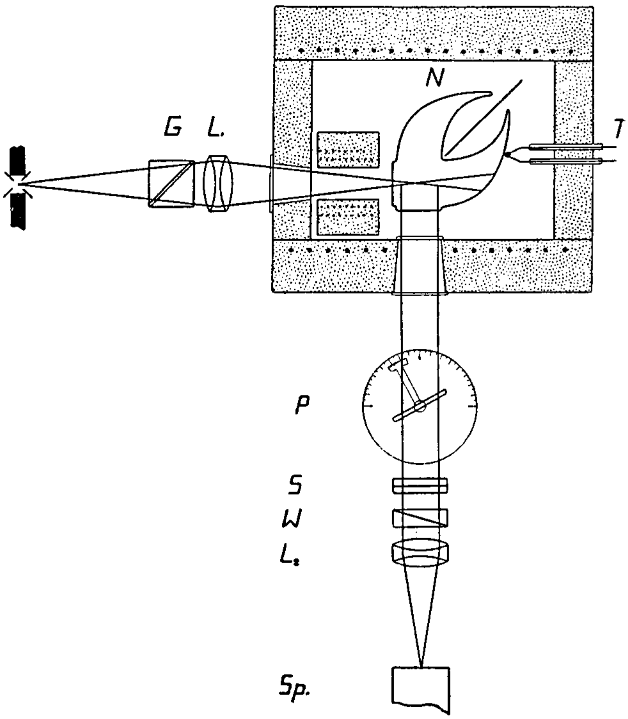

Fig. 1. Diagram of apparatus.

L_1 and L_2 are quartz-fluorite achromatic lenses; *G* — Glan prism;
P — compensation plate mounted on a scaled disc;
S — Savart plate; *W* — Wollaston prism; *Sp.* — Spectrograph.

plate. The sources of light were *Cd, Al, Zn* sparks, all having intense lines in the discussed region and producing a distinct reemission. A Glan prism was used as a polariser. A quartz lens focussed a narrow exciting beam in a quartz tube filled with saturated *Cd*-vapour. The tube had two flat windows and two Wood's horns situated opposite these windows in order to avoid diffusion of the light on the sides of the tube.

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With a Wollaston prism I have got two images of the fluorescence beam polarised in perpendicular planes. The spectra of these beams were photographed with a quartz spectrograph of small dispersion (about 40 Å/mm); the intensity was compared on the plates introducing corrections due to different weakening of both beams by the optical system.

The results seemed to indicate a positive effect, but they were not distinct; therefore I used the Savart plate, together with Wollaston prism as an analyser. The interference pattern was projected on the spectograph slit; the plates could be photometered or the pattern observed directly on the photograph.

For the quantitative evaluation a compensation plate was used; the polarisation as function of the angle between the plate and the direction of the incident beam was calculated by the method used by Gaviola und Pringsheim[1]). This method gives the degree of polarisation with an accuracy of 1%, when spectra are photographed in different positions of the plate. It was possible to use only one plate instead of a whole system because the polarisation was not larger than 15%.

Fig. 1 represents the diagram of the apparatus. The tube N is placed in an electric furnace with two quartz windows. In front of the entrance window is a small furnace protecting the window from the condensation of metallic droplets. A black screen placed between the two Wood horns absorbs the rest of scattered light. The temperature was measured with a nickel-nichrome thermoelement.

The result was that the van der Lingen bands are partly polarised when the exciting light was polarised as well as unpolarised. The plane of partial polarisation is given by the direction of observation and that of the exciting beam.

With the exciting light unpolarised the degree of polarisation P is equal $5\frac{1}{2}\%$; $P = \frac{J' - J''}{J' + J''}$, J' being the intensity of the maximal component, J'' — the intensity of the minimal component. With the exciting light polarised, $P = 11\%$ when observed in the direction perpendicular to the electric vector and $P = 0\%$ in the direction parallel to this vector.

In order to determine the probable influence of collisions on the degree of polarisation, the temperature was changed between $560^0\ C$ and $800^0\ C$. This corresponds to a change of pressure of saturated Cd-vapour from 40 to 1000 mm Hg.[2]) No influence on P was observed.

[1]) Gaviola u. P. Pringsheim, ZS. f. Phys., *24*, 1924.

[2]) In the authors preliminary note in C. R. (loc cit.) a misprint is to be corrected. The pressure of saturated Cd-vapour at $800^0\ C$ is 1000 mm Hg and not 100 mm Hg.

For control it was proved that no influence on P of the magnetic field of the electric furnace containing the tube with *Cd* could be observed. This magnetic field, of several gauss, was parallel to the exciting beam.

The lines of reemission show the same degree of polarisation (with accuracy of 2%) as the surrounding bands. This excludes the possibility of Rayleigh scattering explanation and is in accordance with Kapuściński's point of view[1]) of treating reemission as fluorescence.

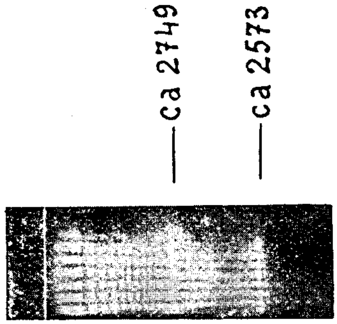

Fig. 2.

One can see the interference pattern crossing van der Lingen bands.
The spectrum lines visible on the picture are the reemitted spark lines of *Cd*.

In the visible fluorescence band of *Cd*-vapour no traces of polarisation were found.

The most interesting is the fact of polarisation of van der Lingen bands, because it seems that no polarisation was observed up to the present time in continuous or fluctuation bands. Polarisation of *Cd* band fluorescence was not expected because of the probably important rôle of collisions in the emission of these bands. According to Winans and Kuhn, the carriers are molecules of very small binding energy in normal state (van der Waals forces) and of quite great energy in the excited state. We have then an emission during a transition from a Franck curve with a deep minimum to a curve with a flat minimum corresponding to larger distances between the nuclei. The influence of collisions must be accepted to explain from this point of view the fact observed by Jabłoński and Kapuściński of exciting the whole fluctuation band with monochromatic light. In all at present known observations of band spectra the collisions have a strong depolarising effect. Here they seem to have no appreciable influence on the degree of polarisation, the time between two collisions changing from 9.10^{-9} to 3.10^{-10} sec. at temperatures varying from $560^0\,C$ to $800^0\,C$. This time is smaller than the usually observed time of life of a molecule in an excited state. We get this time values with diameters given by the kinetic theory. The depolarising influence does not allow to expect smaller diameters and in case of larger diameters the times given above would be still smaller. If the above mentioned point of view on the carriers of the *Cd*-band fluorescence is right, we must accept the partial conservation of the spacial orientation of a molecule in spite of several collisions.

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[1]) Kapuściński, ZS. f. Phys., *73*, 137, 1931.

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Summary.

1. The partial polarisation of van der Lingen fluctuation bands in Cd-vapour was detected.
2. The degree of polarisation P is equal $5^1/_2\%$ for the unpolarised exciting light and $P = 11\%$ for polarised light.
3. Changes of pressure of saturated Cd vapour from 40 to 1000 mm Hg have no influence on the degree of polarisation (with an accuracy of 1%).
4. The reemission lines show the same degree of polarisation as the bands of the background.
5. In the visible fluorescence band no polarisation was detected.

The writer takes this opportunity to express his sincere appreciation of the valuable suggestions given to him by Professor S. Pieńkowski, under whose supervision this investigation has been conducted.

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