Diminishing of Frequency of Light after Diffraction

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Abstract

Laser light fell through a narrow slit into a Lummer-Gehrcke plate. Their interference fringes show a spread of one flank to place of lower frequencies, but there is no displace of the whole line to lower frequencies. This is proved with slit-width below 0.01 mm, in higher orders till some 0.001 mm. So narrower slits, so higher orders of diffraction, and so higher frequency of light, so stronger was the spread of the flank to lower frequencies. Already Smekal predicted diminishing of frequency of light after diffraction.

I. Experimental arrangement

Figure 1 shows the experimental arrangement. A laser, most with radiation-enlarging, illuminated a narrow precision-slit. A Lummer-Gehrcke plate followed in the distance e. With the same success was used plates 5 mm . 22 mm . 200 mm and 3 mm . 15 mm . 100 mm. The interference figure of a Lummer-Gehrcke plate registered a direct behind ordered single-lens reflex-camera with tessar 1 : 4.5, f' = 135 mm on fine-grain film in focal-distance.

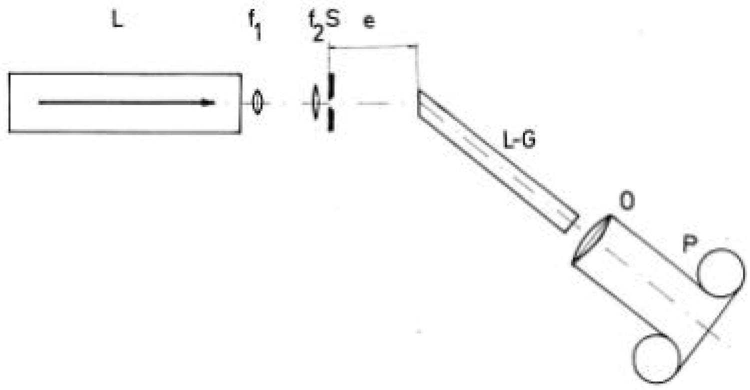

Figure 1. Experimental arrangement. L - He-Ne or Argon laser; f_1, f_2 -lens for radiation-enlarging; S - precision-slit with a maximal width of 0.3 mm; e - distance; L-G - Lummer-Gehrcke plate; O - objective tessar 1:4.5, f' 135 mm; P - single-lens reflex-camera.

Who knows interference-figure of Lummer-Gehrcke plates behind the slit of a spectrometer has to adapt itself if he illuminates with a laser. One gets instead of vertical lines here points for laser-light is parallel bundled. Because diffraction takes place preponderantly perpendicular to slit-edges, the laser-light is still bundled in direction of the slit and the camera-lens imaged this in points in focal-plane. Theoretical a radiation-enlarging of the bundle should vary nothing, but after diffraction bundle is not so rigorous that after radiation-enlarging are to find short lines. This is also profitable by photometry or scanning with radiation-detectors for point-form else can disturb an irradiation. Nevertheless, with or without radiation-enlarging so many scattered lights is present that the customary lines are to see, natural corresponding light-faint.

One could attend to concentrate the radiation with a cylindrical lens on the slit to increase intensity. At larger slit-widths for example 0.2 mm no sharp interference-lines are to obtain because Nieke [1] showed that then the geometrical interference-angle condition is no more fulfilled, where the divergence of the side of illumination is completely transmitted as blur on the side after diffraction. By the narrowest slit-widths an inset of a cylindrical lens was possible but intensity is sufficient that was used no cylindrical lens.

II. Experimental results with a He-Ne laser

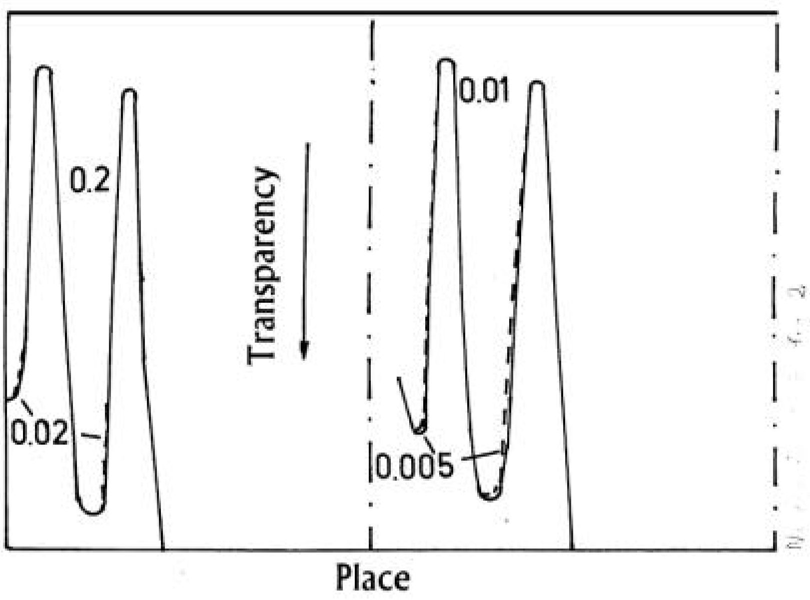

Figure 2. Curves of photometer of the first lines of the Lummer-Gehrcke plate, illuminated with a He-Ne laser HNA 188 with the slit-width 0.2, 0.02, 0.01, and 0.005 mm by e = 0.2 m. The middles of the zeroth orders are examined by varied slit-widths. The optical transparency of the negatives is drawn in arbitrary units in dependence of place of the lines. The dot-lines of slit-width of 0.02 and 0.005 are only there drawn where they deviate from the draw-lines of 0.2 and 0.01 mm. The inner lines are drawn in normalized height. Line-point exhibited the line of symmetry of the photos of Lummer-Gehrcke plate.

First the slit-width was varied and the middle of zeroth order examined. The distance e was chosen to 0.2 m. The two inner lines of one side of Lummer-Gehrcke plate are shown in figure 2. From 0.2 to 0.02 mm slit-width is to see only a trifling spread of outer (here left) fla nks of every line. At slit-widths of 0.01 to 0.005 mm deviations of the here left flanks are more distinctly. For in photos with different slit-widths a full agreeing exposure is not possible therefore the inside located lines by photometry and by drawing are normalized on equal height. The exposure-times are varied and that photo was selectedwhich sufficiently laid in linear sensitometric curve. By narrow slit-widths it is to see that the intensity is displaced to the outside flank of the line therefore to place of lower frequency. By lower frequency of light with normal dispersion the reactive index is smaller and so this part is lying outside.

To test if diffraction and interference superposed undisturbed, or if light runs rectilinearly after diffraction, these results are examined with the larger distance e = 1.2 m. In short distances first theinner diffraction-fringes of the slit appear as already Newton [2] III showed in his 10th observation at the triangular-slit and he inferred that light has to move eel-like. Fresnel [3] established that the space between inner diffraction-fringes of slit or diffraction-fringes of half-plane does not grow linear with distance but in parallel incident light only with the root of distance. It is therefore by no means self-evident that after diffraction light run rectilinear, and non-rectilinear running light would deliver variable interferences.

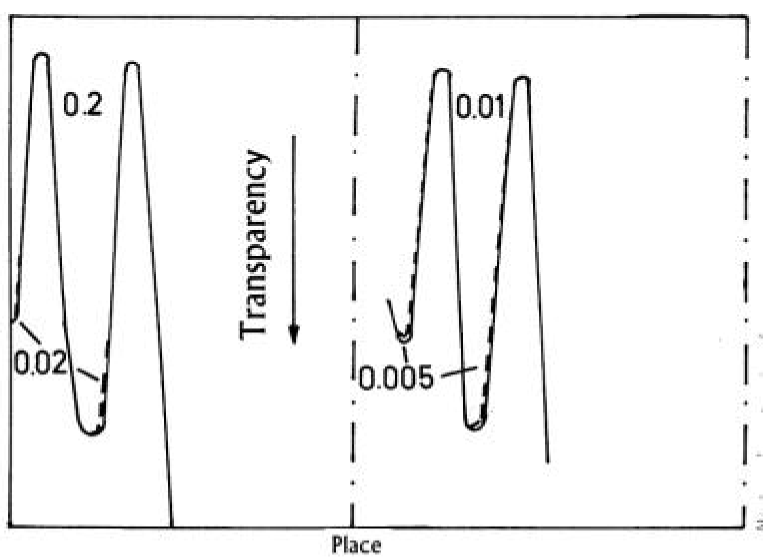

Figure 3. As Figure 2 only e = 1.2 m.

Nieke [4] established that diffractions one after another superpose not undisturbed, therefore the diffraction-figure of slit and that of Lummer-Gehrcke plate must not pass undisturbed. Besides the experiments in figure 3 with e = 1.2 m additionally the here used slit-widths are measured in distances from 0.2 to 1.2 m. The intervals of diffraction-figures grow linear with distance. So it is certain that bent light yields no other interference figure of Lummer-Gehrcke plate here as with undisturbed light.

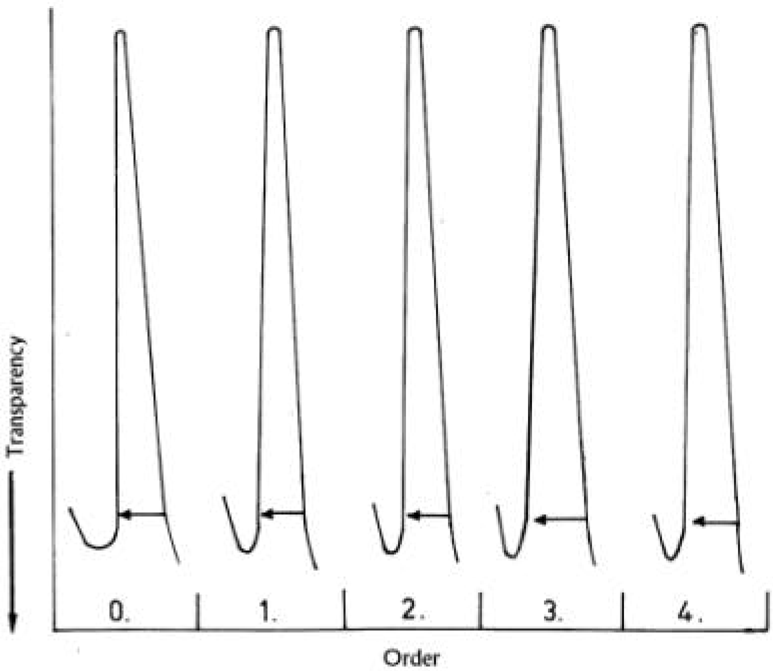

Figure 4. The orders 0 till 4 of the diffraction-figures with a slit-width of 0.025 mm. Drawn is the left inner line of the photometer-curves of Lummer-Gehrcke plate. The arrow at the foot of the curves will direct to the spread in higher orders. The high of the lines is drawn normalized.

Figure 4 shows by a fixed slit-width the results in different orders. The slit-width of 0.025 mm was chosen because one order even illuminated the Lummer-Gehrcke plate. Higher orders of diffraction show a spread at left flanks to lower frequency, so higher the order so higher the spread.

III. Experimental results with an argon-laser

Figure 5 shows the results with the blue-green line of an argon-laser. Already at largest slit-width a fine-structure of this line is to see. It is known that with the strong excitation in this laser a double-line is resulting, this is no result of diffraction. The double-line shows spreading by transfer on the left located line, the line with lower frequency. Then it is to remark that a blue-green argon-laser has a higher frequency as the red of He-Ne laser. After the experiences of Compton-effect were to expect a higher spread. The results at 0.2 to 0.02 mm are only less different. At 0.01 to 0.005 mm slit-width is shown a clear difference. At smaller slit-widths the intensity of outer maxima with lower frequency increase and the ratio of intensity is displaced from inner to outer maxima.

Figure 6 shows like figure 4 single orders of diffraction. Here the above

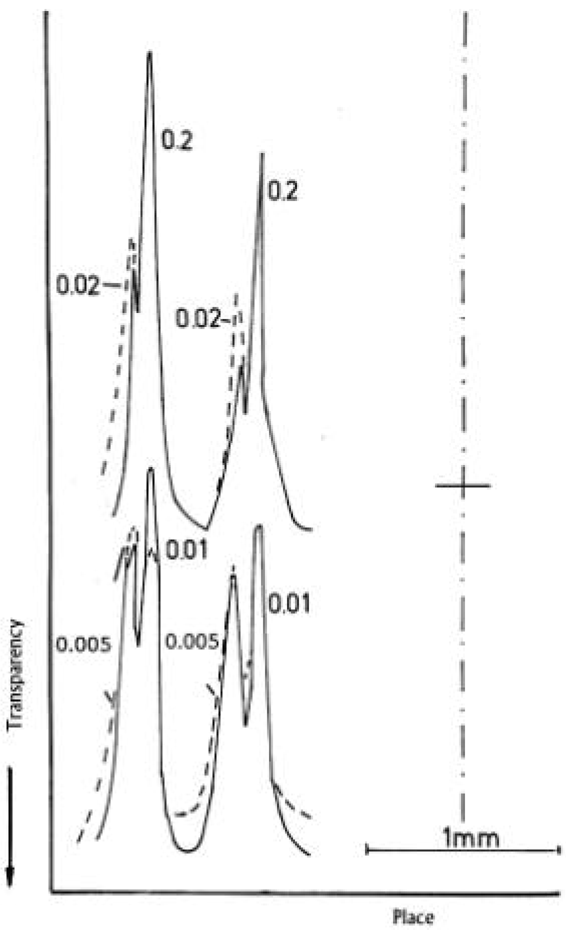

Figure 5. Photometer-curves of the both first left lines of the Lummer-Gehrcke plate. As in figure 2 the zeroth order is examined with varied slit-width. An argon laser ILA 120 illuminated the slit with the blue-green adjustment. In difference to the He-Ne laser the Argon laser yields double-lines. Else as figure 2.

mentioned effect is more obviously because of double-line and greater spread by higher frequency.

IV. Discussion

By knowledge of Compton-effect the red-shift at diffraction is not astonishing. Indeed, who has expected a displacing of the whole line like Hubble [5] found in the spectra of light of external-galaxy nebulas should be disappointed. This is to compare with Compton-effect with summing over the whole angle-reach where also is to expect a spread to lower frequency side. This was here to compare with a sum up over slit-width.

Newton [2] III 5th observation found and Nieke [6] and [7] confirmed that bent light comes only out of the narrow surroundings of every edge. At slit-width smaller as 0.1 mm overlap both spheres where bent light is coming from.

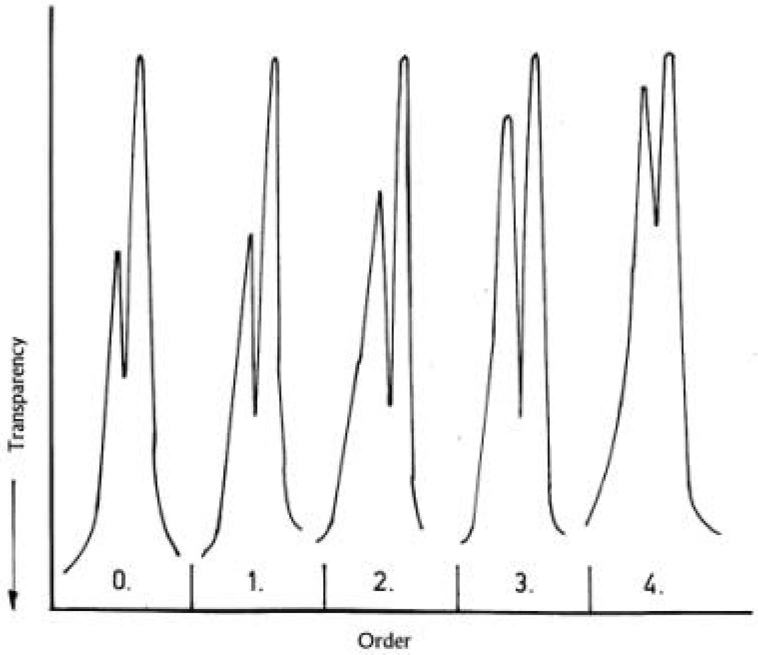

Figure 6. Photometer-curves from negatives which are taken in constant slit-width of 0.025 mm with an argon laser. Shown are only the first left double-lines of the 0^{th} till 4^{th} order where the inner maxima is drawn normalized in equal height.

The ascertainment of slit-width nought is not unequivocal. If one put in slit-width nought in incident light that a movement of slit-yaws is to see, so in transmitted light a first light-perception is to establish in slit-width of 0,001 till 0.002 mm.

Smekal [8] wrote in his paper in which he predicted the Raman-Effekt (translated): „It has the appearance as if with every change of direction of light are connected proceedings of similar quality as described above as 'translation-quantum-transitions'. The formal use of Einstein's impulse-inference then yields on principle a change of frequency resp. diminishing of light at every reflection-, refraction- and diffraction-process, a consequence already W. Duane[9] called attention in a special way independent of the above placed question. A more accurate examination shows that thereby involved deviations of classical wave-theory are to make conveniently interferometric measurable in favourable experimental cases. Till realization of such future-hopes, which are suitable in various respect to destroy the dogma of indispensable of wave-theoretical considerations in optics of reflection and interference, perhaps this is still a very long way."

Raman had exposure-times of hours or days, today with a laser the Raman-effect is to prove in seconds or minutes. So it is no feat to prove diminishing of frequency of light after diffraction with a laser.

The dispersion-range of used Lummer-Gehrcke plate is about

$$\Delta f / f \sim 4\ 10^{-5} \qquad (1)$$

The maximal displacing is only a split of them.

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