Comparative Study of Light-Dark Patterns on CDs (Compact Disks) and Leek Stems as Simple Gratings in Diffraction Grating Practicals

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Abstract
Physics learning often faces a lack of available learning media because it is difficult to obtain or the price is expensive, one example is the diffraction grating practicum. This research tries to improve the limitations of physics learning media, especially in diffraction grating practicum. The use of materials that are more affordable and easy to find, namely leek stems and CD (Compact Disk) as diffraction gratings is an innovative effort for teachers and students to overcome the lack of availability and expensive practical equipment. This research uses experimental methods and aims to compare the light-dark patterns produced by by the two types of grid, namely the leek stem grid and the CD grid. The results of the research show that the light-dark pattern formed from the CD grid has a clearer pattern than the leek stem grid. The distance between the dark and light patterns produced by the CD grid is(15±0,05)×10^(-2)m, while the value for the leek grid is (7±0,05)×10^(-2)m. Thus, it can be concluded that the use of CD chips grid are more efficiently than the use of grids on leek stems as gratings in diffraction grating practice. This innovation provides a concrete solution to the constraints of availability and cost of practical equipment. This allows teachers and students to conduct experiments with more affordable resources. This research not only demonstrates the efficiency of CDs as diffraction gratings, but also contributes to the development of more practical and economical physics learning methods.

Keywords: *Diffraction Grating, Leek, CD*

INTRODUCTION

The implementation of the science learning process should be supported by science equipment, as is the case with physics subjects which require a laboratory to support the learning process. Physics learning often faces a lack of available learning media because it is difficult to obtain or the price is expensive, one example is diffraction gratings.

The diffraction phenomenon can be produced by using natural materials in the form of plant parts as an alternative diffraction grating which has been carried out by Azizah et al (2021) showing that leek stems and banana blossoms have potential and can be used as diffraction gratings to explain the phenomenon of light diffraction (Mutiarani et al., 2021). The results of other research by Supliyadi et al (2010) show that DVDs and CDs can be used as simple spectroscopes and diffraction gratings with the diffraction results from DVDs being denser than the diffraction gratings from CDs (Supliyadi, 2010). Compact Disk (CD) can be used as a diffraction grating because it has a storage track that is sensitive to laser light (Minarni, 2013).

Other research on gratings from natural materials carried out by Wahyuni and Arum (2017) stated that diffraction grating experiments from taro stems (*Colocasia esculenta*) produced diffraction patterns, however the patterns formed were less clear because the stems used were still fresh so the water content in the stems caused the pattern doesn't look perfect (Wahyuni & Prabawani, 2017). The light diffraction experiment using a simple grating by Nuraeni (2019) stated that diffraction phenomena can be produced using lasers and hair, diffraction patterns can be formed with simple equipment and the diffraction concept can be used to carry out indirect measurements (Nuraeni et al., 2019). Laser light is an electromagnetic wave which has the characteristics of being able to experience reflection, refraction, interference, deviation, diffraction and polarization (Kholifudin, 2017).

Light diffraction practicum using gratings made from natural materials and used materials has added value in the world of education because the materials used are cheap, simple and easy to obtain, so these materials can be an alternative solution in dealing with shortages of practicum tools and materials (Aji et al., 2017). Diffraction practicum with natural materials can also improve students' science process skills, so that they can be used in learning(Chasanatun, 2016).

In previous case studies, it was found that the grid width on the CD was (1467.85 ± 16.41) nm and the grid width on leek stems was (15.7 ± 0.6577) mm, but did not discuss the dark pattern. he explained(Supliyadi, 2010). Therefore, in this research, a study was carried out to compare light-dark patterns using a grid of CD chips or leek stems which were clearer against light in the form of a green laser beam entering the grid.

RESEARCH METHODS

In this research comparing diffraction gratings using tools and materials including, a green laser as a light source with a wavelength of 532 nm, a ruler, cutter, tripod, spring onion stems, preparations as a place to place thin spring onion stems, CDs and screens. Wall is used as a screen to capture the pattern that will later be generated.

The research method used is the experimental method. CD disk data was taken and onion stems were used as a grid, then the feasibility test of the model was carried out as a diffraction grating practical tool. In leek stems (*Allium fistolosum*) including the use of diffraction gratings using natural materials. The leek diffraction grating was taken from the thin outer layer of skin on the white leek stem. The outer layer of the leek stem is placed on the preparation as a grid. Meanwhile, the used material diffraction grating uses a CD by removing the outer layer of the CD so that it looks clear so that the laser can penetrate the CD.

The steps for collecting this data can be seen in Figure 2 for the steps for conducting research using a CD and Figure 3 for the research steps using leek preparations. Start by preparing the necessary tools and materials and preparing the grid that will be observed. Then proceed by placing the laser on a tripod and starting to turn the laser on in the direction of the grid by adjusting the distance l until a bright dark pattern is formed on the screen. Next, make sure the light in the room is dark or turn off the lights to make it easier to collect data during practicum. Then take the data by calculating the gap distance from the center point to the first bright point, the center point to the second bright point, and the center point to the bright point.

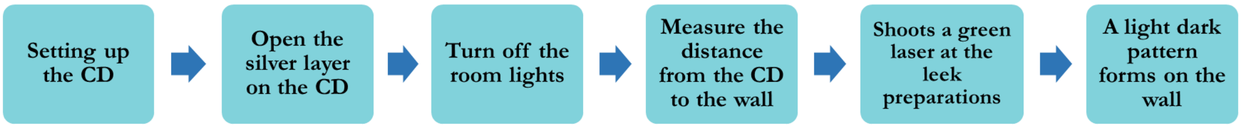
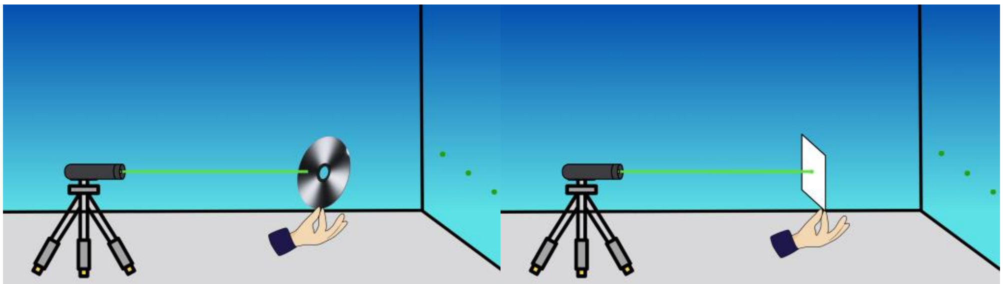


Figure 1. Experimental steps on Compact Disk chips

Figure 2. Experimental steps on Leek Preparations



(a) (b)

Figure 3. Illustration of the data collection process (a) using a CD grid and (b) using a leek stem preparation

In this experiment there are several variables, namely the green laser as a fixed variable, the gap in the CD grid and the leek stem as the independent variable, and the distance or length of the center point to the bright spot, and the wavelength as the dependent variable. In our analysis we also look for the wavelength (λ) using the following equation:

$$\lambda = \frac{d.p}{l.m} \quad (1)$$

then calculate the measurement uncertainty value (Δλ) using the equation:

$$\Delta\lambda = \frac{d.m}{l}\Delta p + dmpl^{-2}\Delta l \quad (2)$$

and then calculate the relative error using the equation:

$$RE = \frac{\Delta\lambda}{\lambda} \times 100\% \quad (3)$$

This relative error is calculated to determine the actual deviation or error when making measurements.

RESULTS AND DISCUSSION

Based on the diffraction grating experiments using CDs and onions that were carried out, the following data were produced.

Green Onion Lattice Light Dark Pattern

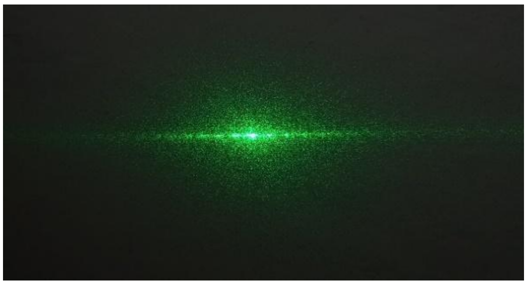


Figure 4. The resulting dark light pattern on the leek grid

Table 1. Diffraction Grating Experiment using slits in leek stems.

Number of Orders (m)	Bright point (T)	Distance between grid and screen (l)	Distance from the central bright spot to other bright spots (p)
1	Tp-T1	1,97±0,1 m	0,07±0,05 m
2	Tp-T2	1,97±0,1 m	0,16±0,05 m

Experiment 1 produced 2 measurement data with the length from the bright spot of light to the other bright spot getting bigger.

Table 2. Analysis of diffraction grating data using leek stem gaps
$d = (15{,}7 \pm 0{,}6577) \times 10^{-6}$ m

Number of Orders (m)	Wavelength (λ)	Measurement Uncertainty ($\Delta\lambda$)	Relative Error (RE)
1	$558 \times 10^{-9}\ m$	1116×10^{-4} m	2 %
2	$638 \times 10^{-9}\ m$	510×10^{-9} m	8 %

In Table 2, the values for wavelength, measurement uncertainty and relative error in both orders are obtained.

Discussion

This experiment was carried out using CD (Compact Disk) chips and spring onion stems to test the effectiveness of light-dark patterns with the working principle of a diffraction grating using the Huygens-Fresnel principle, where Huygens stated that the light that comes out of the grating will become a source of new waves and these waves will becomes a superposed wave that can be used to draw wave fronts from the propagated amplitude(R. Halliday, 2011). This experiment uses a green laser which has a wavelength of 532 nm (Hasanah, 2022). When light comes out of the laser, the light will pass through the grating and spread in all directions behind the grating and will form a superposition wave.

Two experiments were carried out, namely a diffraction grating experiment using the slit of a spring onion stem and a diffraction grating experiment using a CD slit. In each experiment, the distance from the center point to the other bright points will be obtained. Apart from that, the wavelengths produced by the onions and the CD used will also be obtained. Then the wavelength resulting from the experiment will be compared with the wavelength in existing theory.

The first diffraction grating experiment used a slit in a leek stem which had a slit width of $(15{,}7 \pm 0{,}6577) \times 10^{-6}$ meters. In this experiment, the distance used between the grid and the screen was $1{,}97 \pm 0{,}1$ meters. This experiment produces two measurement data with the distance from the center point to the other bright points increasing in value. It can be seen in Table 1 that the experimental data shows that the light dark pattern on the onion lattice is two orders of magnitude. In the first order, the distance between the center point and the brightest point is $0{,}07 \pm 0{,}05$ meters. In the second order, the distance between the center point and the second bright point is $0{,}16 \pm 0{,}05$ meters.

The second diffraction grating experiment used a CD which had a gap width of $(1467{,}85 \pm 16{,}41) \times 10^{-9}$ meters. In this experiment, the distance used between the grid and the screen was $0{,}40 \pm 0{,}1$ meters. This experiment produces two measurement data with the distance from the center point to the other bright points increasing in value. It can be seen in table 3 that the experimental data shows that the light and dark pattern on the CD is two orders of magnitude. In the first order, the distance between the center point and the brightest point is 0.15 ± 0.05 meters. In the second order, the distance between the center point and the second bright point is 0.37 ± 0.05 meters.

Based on diffraction grating experiments using slits of leek stems and CD pieces, wavelengths were obtained from the data processing of the two experiments. In experiments using leek stems, the resulting wavelength was 558×10^{-9} meters with a relative error of 2%. Meanwhile, in the experiment using a CD (Compact Disk), the resulting wavelength was 550×10^{-9} meters with a relative error of 2%. Where, the wavelength produced using a green laser should be meters.

Patterns formed from diffraction gratings using CD chips and onion stems show varying results. The light diffraction pattern formed is not too much and produces little scattering. This shows that the diffraction grating from a CD and onion stems can be used as a diffraction grating. However, a diffraction grating using leek stems produces a light-dark pattern that is not clear due to scattering, resulting in an image that is not very clear and the distance is very small. This can happen because of the water content in the lattice of the leek stems. Meanwhile, in a diffraction grating using a CD, the pattern formed is clearly visible and does not experience scattering.

However, the distance between the patterns formed has a large value and a large screen is needed to get lots of bright patterns.

CONCLUSIONS

Based on the diffraction grating research that has been carried out, the use of natural materials, namely CDs and leek stems, has been successfully used as a simple grating in the diffraction grating practicum. In testing the feasibility of the leek stem lattice model, it produces a light-dark pattern that experiences scattering so that the pattern is not clear, while a lattice using a CD produces a clearer light-dark pattern. So it can be concluded that using a CD grid in diffraction grating practice is more efficient than using a leek grid.

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