Magic of Light

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ABSTRACT

This paper focuses on the concept of the website "Magic of Light", an internet platform that offers podcasts, slides, pictures, Flash animations and educational materials to allow a better understanding in optics and photonics.

Key words: 000.2060 Education, Education in Optics and photonics;

INTRODUCTION

"Magic of Light" is an internet platform that offers podcasts, slides, pictures, Flash animations of optical phenomena, and educational material to allow for a better understanding of optics and photonics. The front page of the website is presented in Fig. 1 and can be accessed via www.magic-of-light.org

The goal of this website is to support education in optics and photonics and to communicate enthusiasm for physics and especially for optics to the young visitors. The website features podcasts that demonstrate experiments and serves in announcing competitions and sharing experience among teachers in optics and photonics. Generally, this site aims at supporting OSA and SPIE in their educational goals.

One important focus of the website is to spread podcasts of two events: The first one is the University for Kids (Fig. 2 and Fig. 3) with a lecture in optics and photonics and the second is the Girls' Day (Fig. 4 and Fig. 5) where topics include the Galileoscope™, merging the interest of astronomy and optics for the young auditorium. To this event, kids from the both sides of the Rhine, Germany and France, are invited.

Figure 1: Website „Magic of Light"

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The content of the website can be accessed after a free registration, during which users obtain their personal login data from the webmaster. In order to register, users have to provide name, occupation, university/school, and a valid e-mail address. Any user has read-only access to the website.
The website is built in a modular way and can be extended and updated easily by supervisors.
The content of the website is divided into two main categories: media-center and info-center

MEDIA - CENTER

The media-center features the following content:

2.1. Podcasts

2.2. Picture Gallery of Optical Phenomenas

2.3. Flash Aminations

2.4. Instructions for experiments

Podcasts

In order to provide effective learning material in the area of optics and photonics, this material has to be well prepared with respect to content, clearness, topics and didactics. The learning aims have to be defined clearly beforehand. These prerequisites are necessary in order to provide the right conditions, especially for recordings of lectures or experimental lectures that should be used for podcasts later on. From literature [1] – [3] and our experience we know that the listenership's attention usually drops significantly after about 20 minutes. For this reason, podcasts that aim at conveying educational material should not exceed a maximal length of about 15 to 18 minutes.

1.1.1 Preliminary Didactical Considerations, Indicated to prepare the Lecture

Among the most difficult aspects that were considered during the preparations preceding this lecture, the age group of the children – between 8 and 12 years – stands out particularly, since the children's previous knowledge in mathematics and physics cannot be assumed. This imposes a problem since this means in particular that the children are unfamiliar with the abstract mathematical modeling of complex processes. Certainly one also needs to adapt both the examples chosen and the language used for explanation, however trying not to lose too much information: As previously stated, we aim for an intuitive grasp of complex concepts and processes occurring in Optics.

The lecture "The Magic of Light" was composed of the following topics:

- light as an electromagnetic wave
- light is energy
- light has a speed
- reflection, refraction and total internal reflection of light
- applications of total internal reflection: optical fibers, optical communication, WDMD
- LASER
- experiments demonstrating the functionality of the LASER
- Applications of the LASER: laser printer, optical data storage (CD, DVD, Blu Ray)
- LASERs in medicine (SPIE poster)

Figure 2: Logo of the University for Children
© University of Applied Sciences Offenburg

Figure 3: Young scientists at a lecture
© University of Applied Sciences Offenburg

We used graphics, animations, a live-stream, PowerPoint slides, and experiments that were conducted in front of the lecture hall. The forms of speech we employed were monologues, dialogues, and in particular the guided conversation. Luckily the children participated actively and also brought in to the lecture an unexpected amount of previous knowledge. Nonetheless they were visibly fascinated by the presented experiments.

The lecture "Galileoscope™" was composed of the following topics:

- light is energy
- light has a speed
- reflection, refraction of light
- lenses
- applications of lenses: Galileoscope™

Figure 4: Logo Girls' Day
© Girls' Day

In contrast to the University for Children, which is an experimental lecture featuring experiments in front of the class, the courses given at the Girls' Day have a more interactive character. In this year we decided to cover the topic "Galileoscope™" after having visited the conference „Frontiers in Optics und Photonics West" and given that the last year was the "International Year of Astronomy".

Figure 5: Girls construct a Galileoscope™
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Lectures of this kind, i.e. lectures incorporating an appreciable amount of experiments, have a very high learning effect – even if the experiments are conducted only by the lecturer. Another guarantee of success is the parallel presentation of the experiments and specifically synchronized PowerPoint slides. This way, the slides operate like instructions for the experiments.

1.1.2 Learning Goals

To guarantee for the success of a lecture or an experimental lecture with practical work, a correct and precise definition of the learning goals [4] that should be achieved is necessary. Once more, we have to stress the importance of the proper adaptation of the lecture to the listeners' age group of 8-12 years for the University for Children and 12-19 years for the Girls' Day.

The most important learning goal we set up for the lecture was to convey fascination for science (physics in general and optics in particular) and technology to the young audience, since the curiosity and thirst for knowledge of children in this age group is enormous. We point out that the knowledge children in this age groups achieve with fun is knowledge they can use for their whole life – furthermore, knowledge that has been achieved with fun can also be used creatively later on. This presents an outstanding premise for the potential scientists of tomorrow.

Considering the taxonomy of learning goals proposed by Bloom [5] – [9], we can claim that the learning goals we imposed on the lecture reached level K4 for the University for Children and K4 – K6 for the Girls' Day:

- Knowledge (K1): Precise (if not literal) reproduction of information
- Understanding (K2): Ability of applying sense-preserving transformations to knowledge, ability of paraphrasing knowledge in own words and finding examples;
- Application (K3): Ability of applying abstractions, rules, methods, algorithms etc. in concrete situations;
- Analysis (K4): Ability of decomposing ideas and problem settings into its elements and comparing problems, spotting differences;
- Synthesis (K5): Composition of individual elements to a whole;
- Evaluation (K6)

The most important goal of these lectures is to spread enthusiasm for physics and especially for optics to the children. We were aiming at an age-adapted understanding of fundamental concepts such as reflection and also tried to enable the children to reproduce the ideas of refraction and total internal reflection. Furthermore we presented interesting applications of optics such as the optical fiber, the laser and their applications at the University for kids lecture, and telescopes and Astronomy at the Girls' Day lecture. (Fig. 6)

Figure 6a: Discovering the Galileoscope™
© University of Applied Sciences Offenburg

Figure 6b: Reading the instructions
© University of Applied Sciences Offenburg

Figure 6c: Testing the self-made Galileoscope™
© University of Applied Sciences Offenburg

Picture Gallery of Optical Phenomena

The goal of this section is to present a gallery of images depicting interesting phenomena arising in optics and photonics. Each image features an explanatory text including the content of the image, the physical background hidden behind the image, and the way it was recorded by whom, where and when (Fig. 15). From time to time, small photo contests can be announced. Respecting copyright law, only pictures will be published that have been created by students and professors. The figures below (Fig. 7 – Fig. 14) show some images included in our gallery up to now.

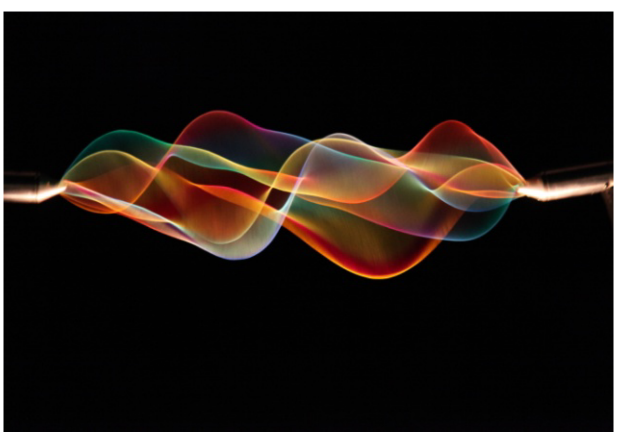

Figure 7: Wave machine – nonstationary state
(photographed at Technorama - The Swiss Science Center[2])

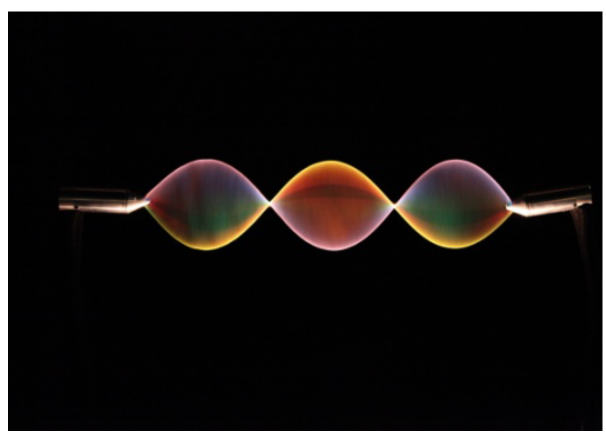

Figure 8: Wave machine – stationary state
(photographed at Technorama - The Swiss Science Center)

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[2] www.technorama.ch

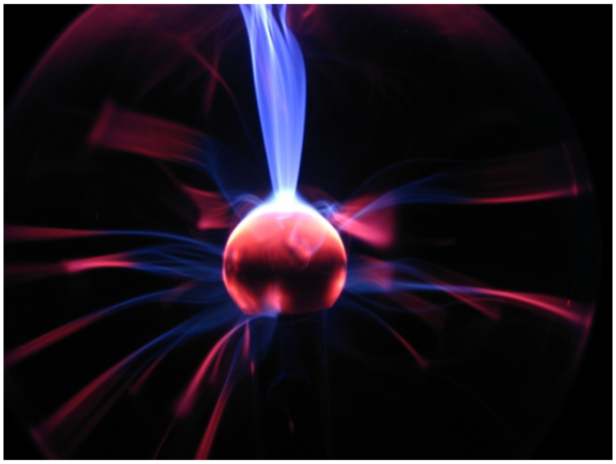


Figure 9: Tesla coil

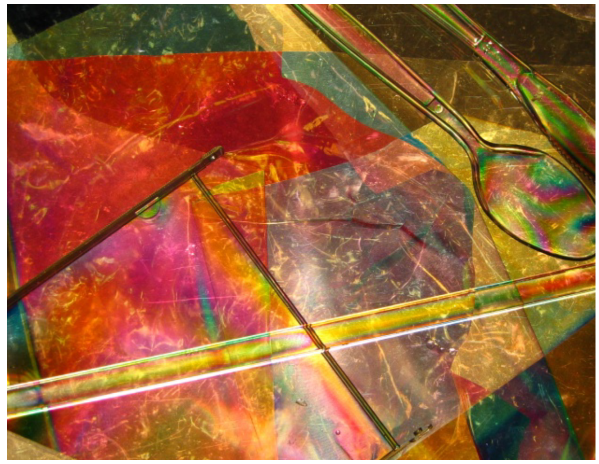


Figure 10: Cross polarization

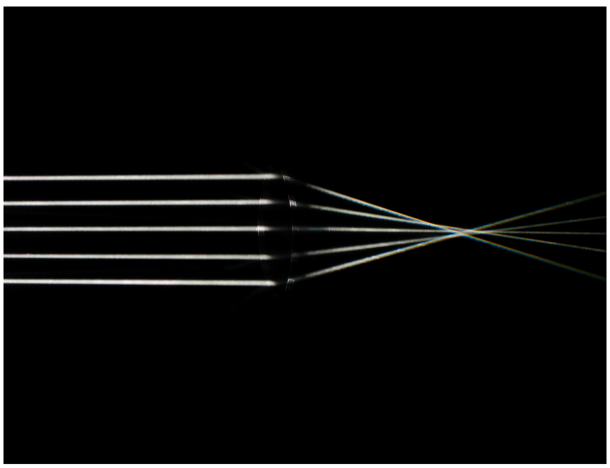


Figure 11: Convergent lens

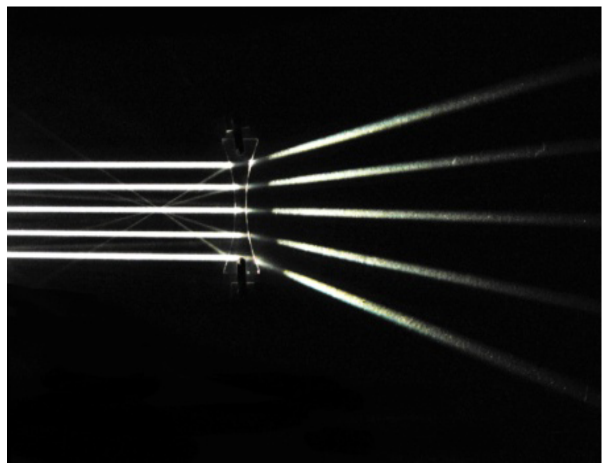


Figure 12: Divergent lens

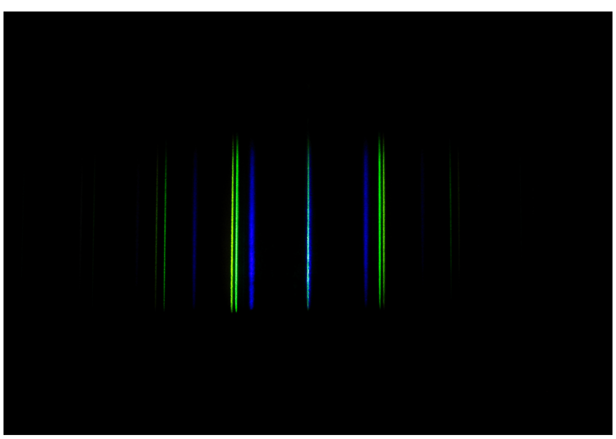


Figure 13: Interference pattern

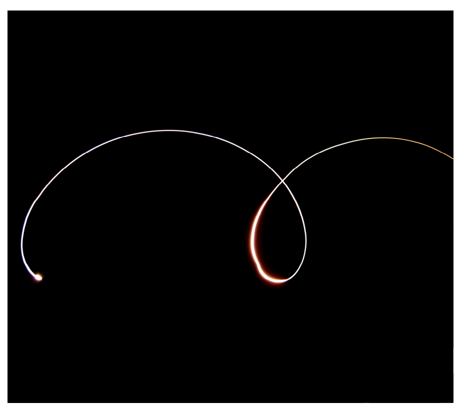
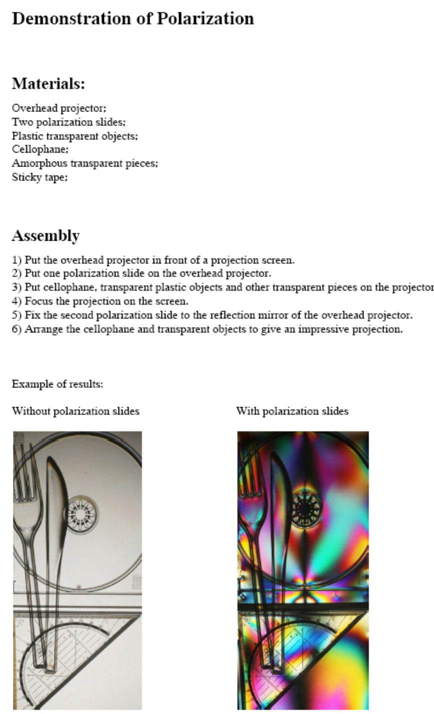


FIGURE 14: CYCLOID BY RAY TRACING

Fig. 15: Website of the picture gallery



Demonstration of Polarization

Materials:

Overhead projector;
Two polarization slides;
Plastic transparent objects;
Cellophane;
Amorphous transparent pieces;
Sticky tape;

Assembly

1) Put the overhead projector in front of a projection screen.
2) Put one polarization slide on the overhead projector.
3) Put cellophane, transparent plastic objects and other transparent pieces on the projector.
4) Focus the projection on the screen.
5) Fix the second polarization slide to the reflection mirror of the overhead projector.
6) Arrange the cellophane and transparent objects to give an impressive projection.

Example of results:

Without polarization slides | With polarization slides

Fig. 18: Instructions for experiments

Flash Animation

Pictures tell more than words: By the help of suitable figures and posters, the children were exposed to new views of the world. Combining these figures with animations, one can achieve even more of the learning goals previously described: Animations convey functional interdependencies better than static images. The young audience was obviously fascinated by the images and animations. Quite often we noticed during the lecture that precise questions concerning further applications and relationships to other areas were asked.

The animations were introduced in order to polarize the interest of the young audience. Since children usually like cartoon animations, we assumed a natural affinity for scientific animations. We used animations to demonstrate the functionality of optic fibers and the WDMD and to show the ray trace in Galileoscopes™ and Kepler telescopes.

A good animation has to be self-explanatory, should impress and should also be memorable since we want the children to remember the information conveyed by the animation later on in order to use it creatively. If a picture tells more than thousand words, an animation can tell more than thousand pictures [10]. Some animations have been prepared in PowerPoint and accompanied the conducted experiments like instructions.

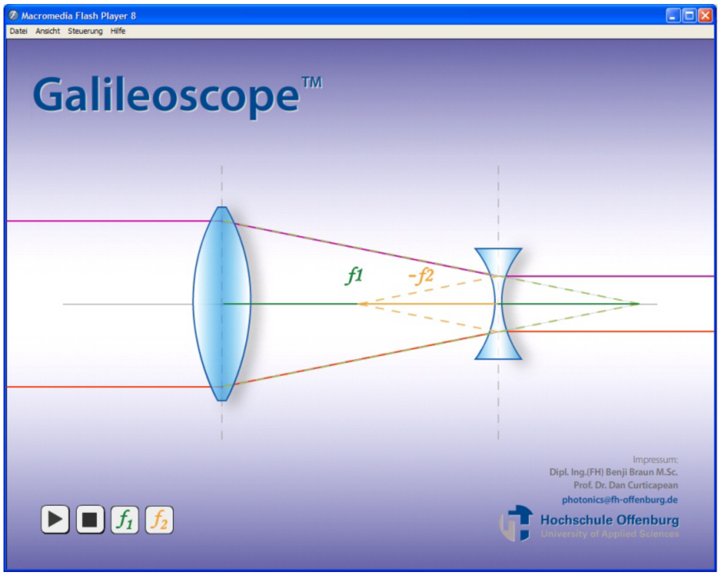


Figure 16a: Galileoscope™, optical path

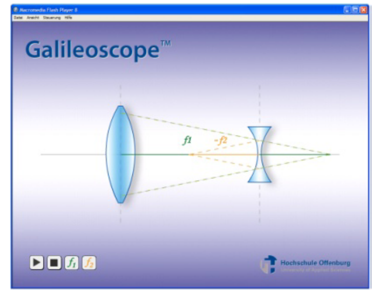


Figure 16b: Galileoscope™, lens geometry

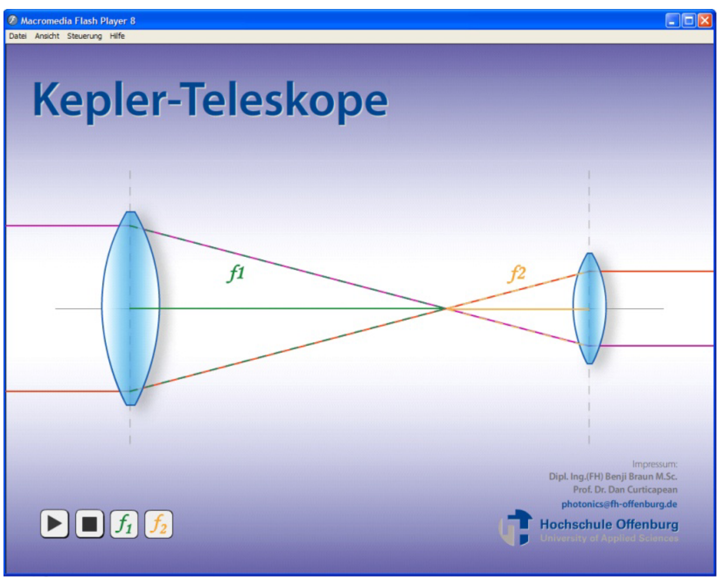


Figure 17a: Kepler Telescope, optical path

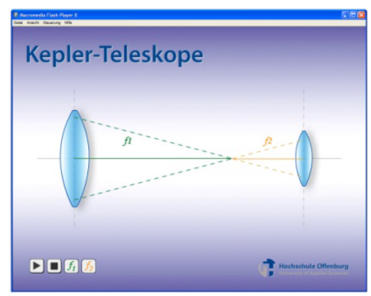


Figure 17b: Kepler Telescope, lens geometry

Instructions for Experiments

As we consider experiments to play a key role in education related to optics and photonics, we provide instructions for experiments in this section. As depicted in Fig. 18, these instructions are kept easy and follow the following structure:

- experiment title
- required material and components
- assembly
- sketch of the experimental set-up or an image of the result

INFO-CENTER

In the info center, events and news are shown and a collection of useful links is provided. Among these, links to the educational sections of the SPIE and OSA can be found here. Another category of links leads to live events such as:

- The Eclipse Live homepage that broadcasts astronomical events such as lunar and solar eclipses live in the internet (Fig. 18)
- The eco-marathon homepage that broadcasts the Shell eco-marathon in Europe. In this contest, specially built vehicles can drive up to 4,500 km with only one liter of fuel. Solar vehicles also participate in this contest. (Fig. 19)

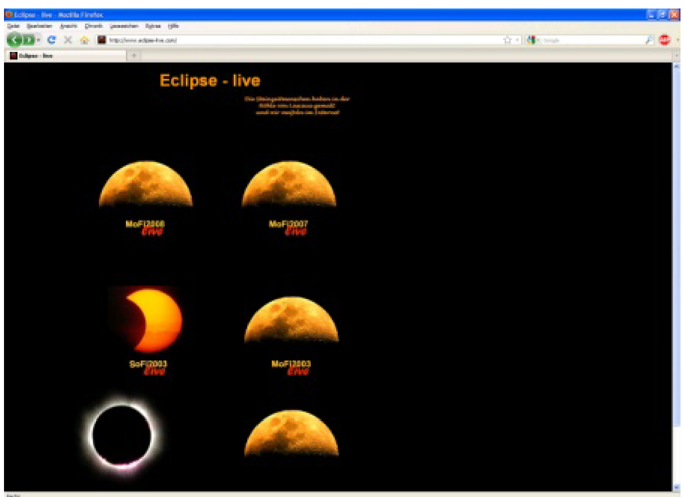


Figure 18: Front page of the website eclipse-live.com

Figure 19: Front page of the website eco-marathon.de

Live Broadcasting

Live broadcasting can be integrated into a lecture in order to make outdoor experiments possible and to connect with other simultaneous events that may happen worldwide. Furthermore, it enables the young audience to observe an experiment from different angles of view. For a live broadcasting it is also necessary to establish a bidirectional audio connection with the lecture hall. This enables to react to the auditorium's wishes and to repeat the experiment for several times.

An example for live broadcasting was an experiment involving a fire truck at the University for kids (Fig. 20).

Figure 20: Preparations for the live broadcast of the experiment involving the fire department

Another live broadcast will be prepared by our students for the “Science House” in our district. Here, pupils will be informed about interesting professions such as astronauts, polar scientists, doctors in operating rooms and operators of hydroelectric power plants. To this goal, live broadcasts to the corresponding scientists will be established that pupils can use to ask questions.

CONCLUSION

As a general conclusion, we can claim that the children had much fun during the lectures. This was emphasized by repeated applauses and calls for encore. In the lecturer’s point of view, the learning goals have been achieved and – in some situations – even exceeded by the children’s unexpected collaboration and previous knowledge that they applied successfully. Furthermore, we are quite convinced that the experiments will stay in the children’s minds.

Last but not least the children were positively surprised by the events.

Together with colleagues from the Laboratoire des Systemes Photoniques from the University of Strasbourg, we intend to extend this experience considering also the ecological aspects of photonics.

Acknowledgements

It is common practice to welcome the participants of the events with a small present. By the kind support of the Thorlabs Company, we were able to offer to each participant of the University for Children a ball pen with an impressive integrated LED illumination. We once more want to thank Dr. Angelika Küng, manager at Thorlabs, for this. The gift for the Girls´ Day was donated by our University. Thanks also to Edeltrad Veit-Kiefer, Elke Schiffler, Nadine Stammler and my colleague professor Walter Großhans for their help and assistance at both events.

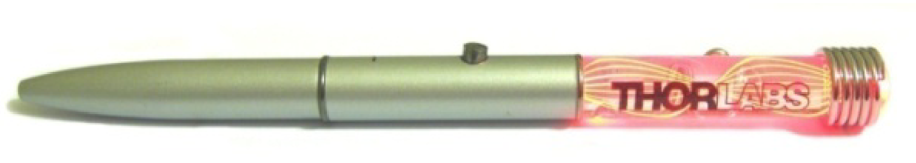


Figure 21: Present for the participants at the Children's University

Figure 22: Present for the participants at the Girls´Day

Thanks also to the SPIE and the OSA for their kind support with the excellent learning aids (posters, movies) published on their web sites.

For their involvement in the lecture "The Magic of Light" we also want to thank the fire department in Offenburg. Without their help, one substantial experiment could not have been presented so impressively.

Also I want to thank Larissa Wunderlich, a former student of our University, for the design and implementation of the website www.magic-of-light.org

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