Education and Heritage in the era of Big Data in Astronomy
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Herschel and the invisible end of the rainbow

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Abstract. The communication project "Herschel and the invisible end of the rainbow" features the year 1800 discovery and today's application of infrared radiation through diverse methods and different media in order to reach a wide audience. The discovery of the sun's infrared radiation by the Herschels is demonstrated in a creative way through the publication and performance of a theatre play and accompanying audio play. The documentation of the historical discovery, which changed both science and our daily life, is further supplemented by background information e.g. on the role of women in science in the late 18^{th} and early 19^{th} century. By this, the history of the discovery of infrared radiation becomes alive and easily comprehensible. Additionally, we carry out interactive experiments and demonstrations using a capable thermal infrared camera by which a mostly unknown and strange infrared world becomes visible for all generations. Our recent findings with the infrared space telescope Herschel are used to exemplify modern science use. With this colourful, diverse and interactive communication concept, which is easily extendable and adaptable, we already took part in several science festivals, workshops and training events.

Keywords. history and philosophy of astronomy, Sun: infrared, infrared: general

1. Introduction

While studying heat and colours, William Herschel discovered infrared radiation by chance in already 1800 (Herschel 1800 and other related papers in the same volume). It was the first *invisible radiation* that was not pure magic but was probed in a systematic way (Fig. 1). in 1801 already ultraviolet followed but other forms of invisible light only much later – radio waves in 1886 or X-rays in 1895. Today, infrared light is widely used for science and technology.

William Herschel was not working alone. Over most of his career his sister Caroline Herschel was a congenial partner. (Fara 2004, Hoskin 2005). Caroline started as assistant but over the years developed her own projects and published independent papers on e.g. comets, stellar clusters, nebulae and double stars. From 1787 on she got paid for her work by the crown, in 1828 she received the Gold Medal from the RAS, of which she became honorary member in 1835.

In order to complement our scientific work with ESA's Herschel Space telescope and our technical developments for its instrument PACS we initiated an FWF outreach programme (https://www.fwf.ac.at), which communicates the historical perspective of the original discovery of infrared radiation, provides educational hands-on experience with infrared radiation and spectroscopy, highlights the teamwork of the Herschel siblings, and the pioneering role of Caroline Herschel for women in science. The project uses a wide range of means to communicate – from art to experiment and combines several educational elements with outreach to the general public.

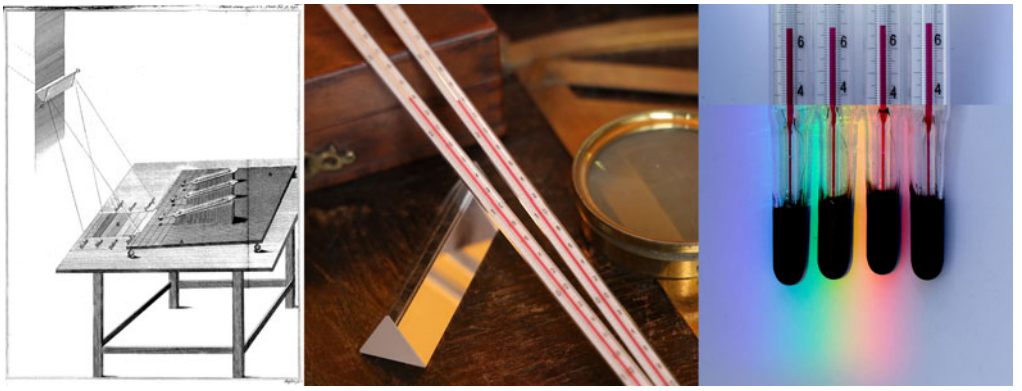

Figure 1. f.l.t.r. Herschels orginal experiment; our instruments; typical temperature readings.

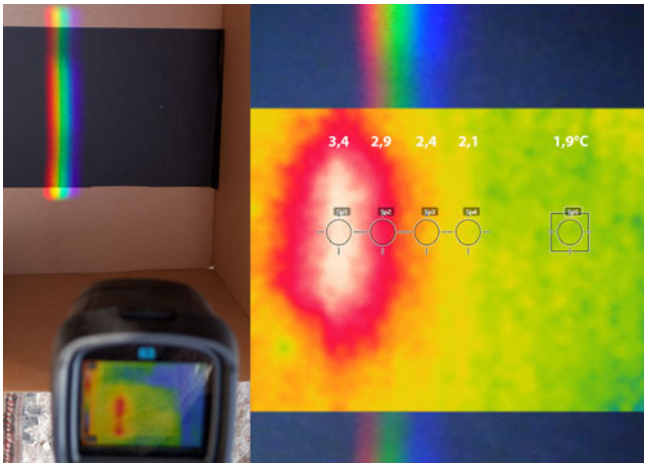

Figure 2. f.l.t.r. Liveview of *FLIR E8* thermal infrared camera of solar spectrum; superposition of visual and infrared spectrum incl. temperature readings.

2. Experimenting with visible and infrared radiation

Redoing the original Herschel experiments was the starting point of our activities. It began with research on cheap and accessible materials like thermometers and prisms and needed quite some finetuning to make repeatable solar measurements also in warmer environments (see Fig. 1). We were actually quite impressed how the Herschels made it happen when trying to replicate their experiment. Because of its relatively tricky setup with sometimes only marginal results it was not used further for our give-away experiments, the Aha!Boxes (see Fig. 5).

Today, we have other means to detect infrared radiation! With a thermal infrared camera like our *FLIR E8* (Datasheet: https://tinyurl.com/y3w4t3tx) the solar spectrum we used for our thermometer experiments can be simultaneously imaged in visible and infrared light. As shown in Fig. 2, the camera was used to measure the different temperatures of black paper illuminated by a winterly solar spectrum. An overlay of a visual image to the thermal one proves the spatial offset between the visual and infrared maximum of radiation.

Such a thermal infrared camera is also a perfect hands-on tool for the interested public. It directly shows how different the world looks like with *thermal eyes* as depicted in Fig. 3.

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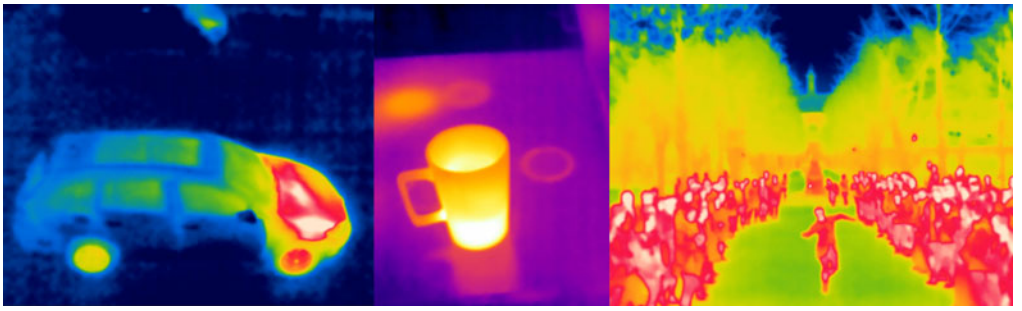

Figure 3. Typical FLIR E8 infrared images: f.l.t.r. Car; coffee mug; dancer in a park.

Figure 4. Demonstration of thermal infrared camera at public science fair.

People can experiment by themselves. Several applications in e.g. health or for thermal insulation purposes are easy to understand – and it is really fun!

Our thermal infrared camera was also the *star* at several science festivals and outreach events (Fig. 4) and reached very wide audiences and media coverage. The *Dance for Science* event combined art and science in a "moving" way (rightmost picture in Fig. 3). During the *Viennese Ball for Science* we streamed one of the ballrooms in infrared light and even had a *hottest dancer* contest. This entertaining part was accompanied by poster displays on related science projects.

Especially for kids hands-on experiments are crucial for impactful educational contributions. With our *Aha!Boxes* (https://ahaboxes.org/), which are small experiment boxes, we try to initiate experiments with light. As depicted in Fig. 5 one can do spectroscopy, spin a colour wheel, colour cartoons, and play Herschel theatre. The free give-away German and English boxes were produced together with the *Indian Manthan Educational Programme Society* (https://mepsindia.org/) in a social enterprise.

3. In the media and on stage

In parallel to the experimentally oriented activities, several online podcasts, interviews and videoclips round up our educational program on infrared radiation. Scientists speak about their research projects, historians highlight the societal context. In COVID-19 home-office and home-education times we also produced short feature video clips on infrared radiation and the science and technology behind.

From the beginning our aim was to offer as many as possible different and complementary means of communication. In doing so, one very special key element is our newly written 30min theatre play (Heger & Artacho 2018) where one can join the Herschel siblings during their experiments and learn about their work in an entertaining way. So

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Figure 5. Aha!Boxes; solar spectrograph; colouring book; cut out "Herschels".

Figure 6. The authors playing Caroline and William Herschel, discovering infrared radiation.

far it was played by scientists (Fig. 6) at big science fairs and exhibitions. It is typically accompanied by topical talks on modern infrared science projects and hands-on activities with infrared cameras. All needed materials and scripts are available in German and English to everybody. Some first schools showed interest to stage the play themselves.

All elements of our project are documented and accessible via our webpages, both in German and English (https://space.univie.ac.at/en/projects/rainbow/). There one can learn about the historical discovery, redo the critical experiments, watch and listen to

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related podcasts and interviews, the theatre play and its scripts and get our *Aha!Boxes* and experiment yourself!

References

Fara, P. 2004 *Pandora's Breeches: Women, Science and Power in the Enlightenment* (Pimlico)
Heger, M. & Artacho, A. 2018 *Herschel and the invisible end of the rainbow, a play* (https://space.univie.ac.at/en/projects/rainbow/downloads/)
Herschel, W. 1800, *Philosophical Transactions of the Royal Society of London*, 90, 284
Hoskin, M. 2005 *Caroline Herschel: the unquiet heart. Endeavour* 29/1, 22

https://doi.org/10.1017/S1743921321000351 Published online by Cambridge University Press