COLOURFUL PICTURES FROM SPACE

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AiM is a non-profit educational initiative. Our aim is to promote astronomical education in the city of Münster and the surrounding area.
In cooperation with FTP-Europlanet, the students are able to control large robotic research telescopes worldwide, such as the 2.0m Faulkes telescopes on Mt. Haleakala in Hawaii and at Siding Spring in Australia. We call it "Astronomy 2.0".

EDUCATIONAL CONTEXT

AGE

This activity is aimed at students aged 14 and over.

DURATION

The activity takes 1 to 4 hours, depending on the intensity.

PREREQUISITES

The students should be able to use digital devices (notebooks, tablets, etc.) in a rudimentary manner. No further special requirements needed.

EDUCATIONAL OBJECTIVES

COGNITIVE OBJECTIVES

- Get to know various astronomical objects in deep space (galaxies, nebulae, etc.)
- Recognize that different structures represent different types of objects (planetary nebulae, galaxy types, etc.)
- Be able to explain the colors of stars by their temperature

AFFECTIVE OBJECTIVES

- Finding initial access to the universe.
- Get to know the colorful world of the universe
- Experience that colors can appeal to emotions on the one hand and have a physical meaning on the other
- Experience the wonderful information content of the World Library (Internet)

PSYCHOMOTOR OBJECTIVES

- Be the Master of our own digital device
- Manage data on the internet
- Analyze astronomical images
- Independently work out explanations for the various objects with the help of internet research

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CONNECTION TO THE CURRICULA

- Earth and Space (Sec. Level 1)
- Celestial objects (Sec. Level 1)
- Distances in space (Sec. Level 1)
- Astronomical methods (Sec. Level 1)
- Media literacy (Sec. Level 1 & 2)

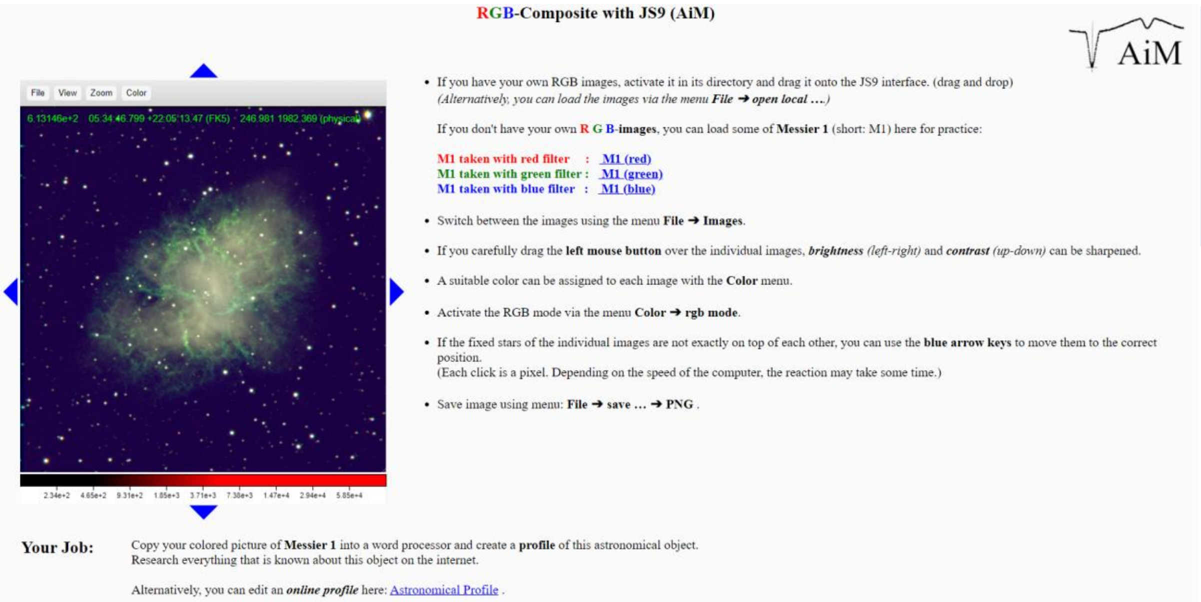
EDUCATIONAL APPROACH

The students are given the task of working on the online worksheet "RGB-Composite":
http://aim-ms.de/.cm4all/mediadb/html/demos/js9_RGB_en.html

The worksheet is system-independent and browser-based. It should run stably on all digital end devices.

The supervisor can concentrate on providing individual assistance (downloading image data, finding image data on their own computer, etc.). Students should also be motivated to support each other.

This could be a possible interim result:



ORIENTING & ASKING QUESTIONS

At this point, it could be useful to share the students' experiences and discuss the results.
The students usually have questions:
Why don't astrophysicists usually use color cameras?
Which of the many results has the right colors or what does the object really look like?
Why are the individual pictures shifted?
What do you see here anyway?
etc.

These questions can be addressed with varying degrees of intensity depending on the time:
- brief explanation of the human eye (possibly a presentation)
- brief reflection on how an alien (e.g. intelligent lizard creature) would judge the images (philosophy)
- ....

(Some hints and possible answers in the APPENDIX.)

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The question “What do you see here anyway?” leads the students to an independent Internet search, which can be carried out using the astronomical profile:
http://aim-ms.de/.cm4all/mediadb/html/demos/Steckbrief_01_en.html

Working hint:
1. Copying from the Internet is permitted provided the source is cited!
2. Never copy statements that you cannot explain when presenting the results!

ANALYSIS & INTERPRETATION

The Astronomical Profile can also be assigned as homework.
Important is
1. the presentation of the results,
2. suggestions for improvement by the classmates and the teacher,
3. correction by the author or authors,
4. exhibition of the results inside or outside the classroom, possibly also in a social medium (internal school platform).

This is one of the possible results (in German):

Astronomischer Steckbrief

AiM

Name des Objektes : **M1**

evtl. weitere Bezeichnungen : **Krebsnebel, Krabbennebel, Crab-Nebel, Crab Nebula, Messier 1, NGC 1952**

Objekttyp : **Überrest einer Supernova**

Masse : ./.

Region :
◉ Nordhalbkugel
○ Südhalbkugel

RA : **05:34:32.0**
DC : **+22:00:52**

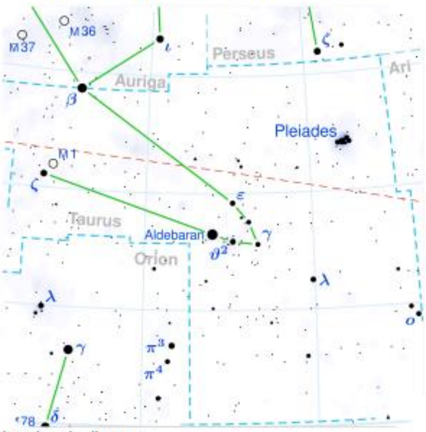
Sternbild :
Stier

Entfernung : **4900 Lichtjahre**

Scheinbare Helligkeit : **8,4** mag

Scheinbare Größe : **6′ × 4′**

Aufnahmedaten :
Datum: 28.09.2022 ; **Uhrzeit :** 15:04 **UTC**
Beobachtungsort: Haleakala Observatory/Hawaii
Details zu den Aufnahmen:
3 Aufnahmen á 180s, Filter: RGB, 2.0m Faulkes Telescope North

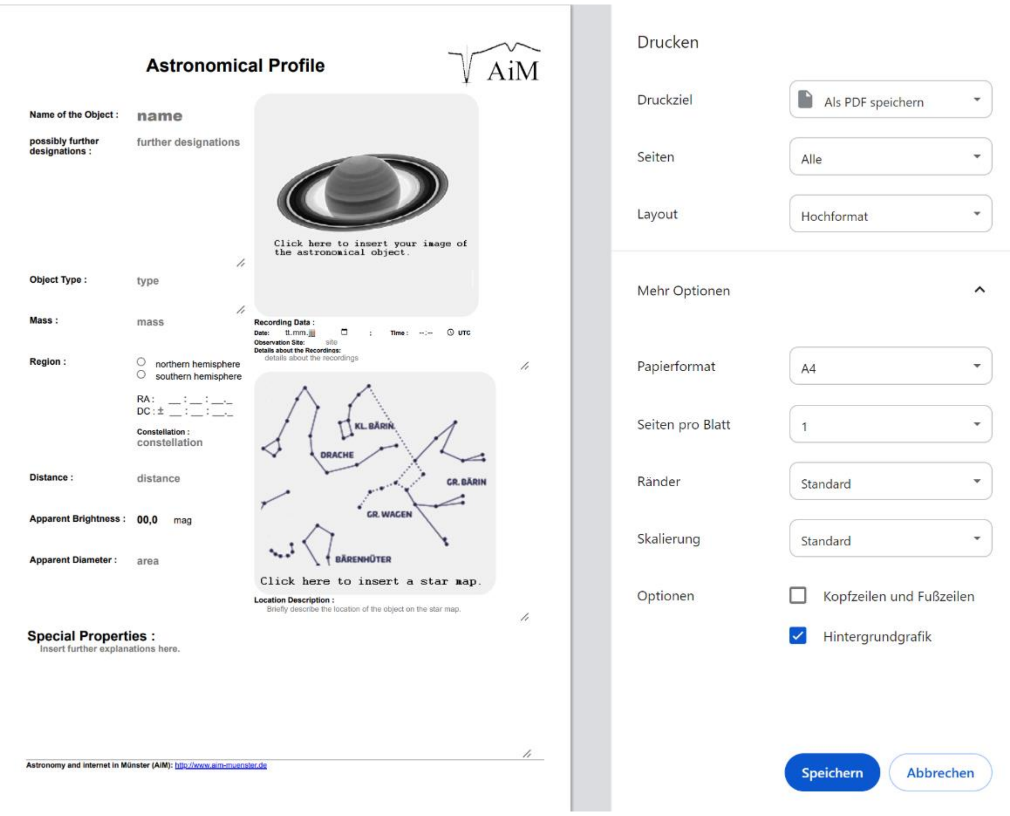


Lagebeschreibung :
Zum Aufsuchen schwenkt man vom Stern ζ Tauri aus 1,2° in Richtung Nordwesten.

Besondere Eigenschaften :

Der Krebsnebel im Sternbild Stier ist der Überrest der im Jahr 1054 beobachteten Supernova, in dem sich ein Pulsarwind-Nebel gebildet hat. Er befindet sich im Perseus-Arm der Milchstraße und ist etwa 1900 Parsec von der Erde entfernt. (Wikipedia.de)
Messier 1 steht in den Wintermonaten hoch im Süden im Sternbild Stier. Zum Aufsuchen schwenkt man vom Stern ζ Tauri aus 1,2° in Richtung Nordwesten. Unter dunklem Landhimmel ist der Nebel bereits mit einem 10×50 Fernglas als kleines, mattes Fleckchen zu sehen. (Astroshop.de)

Working hint:
Use the browser function “Save as PDF” to save the astronomical profile.
Possible procedure:
1. Right-click on the astronomical profile.
2. Select “Print” in the menu.
3. Select the printer settings so that everything fits on one page.
Example:



4. Select printer or “Save as PDF”.

CONCLUSION & EVALUATION

This activity provides a **first quick access** to the universe that meets the primary expectations of most students. Basic skills in the use of astronomical image files and astronomical analysis can be practiced. Pupils learn important terms during the research, but these need to be fixed by didactic measures (vocabulary booklet, ...).
In a second round, different objects should be worked on! Highlights are, of course, own recordings with the possibilities of the Las Cumbres Obserbatory (LCO), especially the Real-Time Slots of the two Faulkes telescopes in Hawaii and Australia.
The MENU of JS9 (online worksheet) has been didactically reduced to the necessary options for the color display of astronomical objects.

With the basic knowledge acquired in using JS9, further MENU points can be introduced step by step, for example to track the movement of objects (asteroids, comets, ...).

With this **orientation in the space environment** and the first contact with a simple **astronomical program JS9** (online worksheet), a good foundation for “students as planetary defenders” has been laid.
Professional astronomical programs, such as “astrometrica”, work on the same principle and can easily be supplemented later.

Continuation: “Moving Objects”

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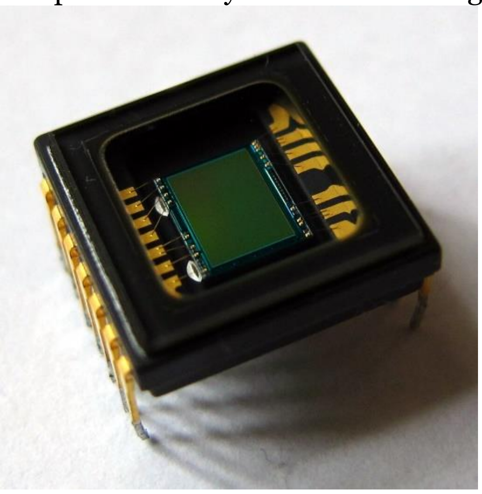
StAnD

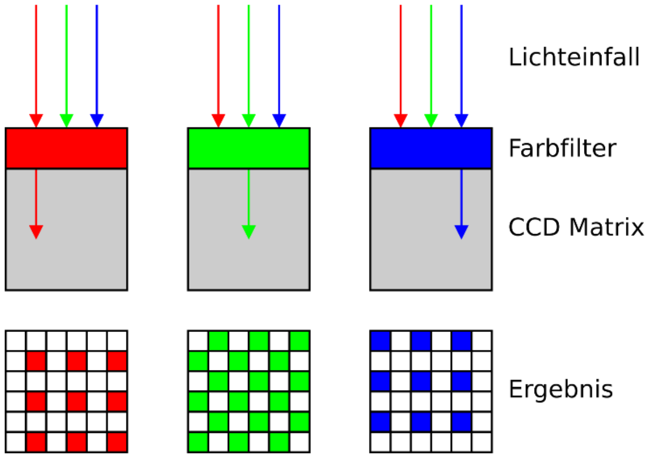
APPENDIX

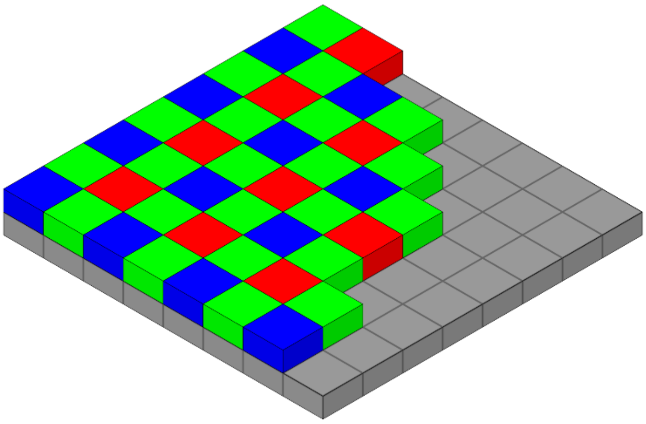
Some possible answers to common student questions:

Why don't astrophysicists usually use color cameras?

Light-sensitive photo sensors (CCD and CMOS chips) work by means of the internal photo effect: during the exposure time, the light triggers electrons in the individual cells (pixels) of the chip, which are stored there until the end of the exposure time. When the chip is read out, each pixel is assigned a numerical value (gray scale) according to the number of these triggered and stored (photo) electrons.
If you want to produce color images that are adapted to the human eye, you have to specifically address the three color receptors in the red, green and blue range of the spectrum in the human eye. For this purpose, Bessel or Johnson filters are used, which transmit or absorb the light relatively well according to the statistical sensitivity of the three human color receptors in the eye. The absorbed light is lost in the process.







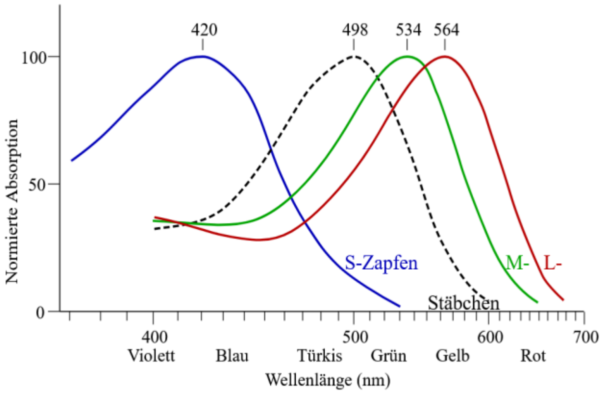
In modern color cameras, the individual pixels are alternately covered with such color filters. Due to the higher sensitivity of the human eye, there are usually twice as many green pixels in the green area as blue or red pixels.

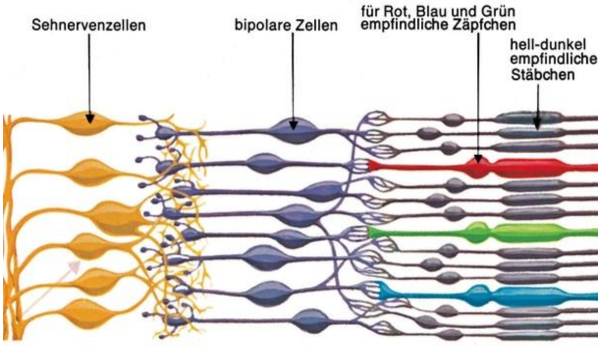
The disadvantage of these color cameras is that at least 1/3 of the light is lost in each pixel and therefore on the entire chip. For this reason, such cameras are only used for bright objects. Astronomers and astrophysicists, on the other hand, are more interested in faint objects in the night sky. In addition, only 50% of the chip area is sensitive to green light and 25% each to red and blue light. Accordingly, the resolution (number of pixels per cm^2) of a color chip is reduced by 50 % in the green range and by 75 % in the red and blue ranges compared to a B/W chip without a color filter.

As most astronomical objects hardly move due to the great distance, astronomers prefer to take individual color images one after the other by placing the desired color filter in the entire beam path. This also has the effect of making the choice of filter more flexible. There are special filters for detecting certain elements, e.g. hydrogen, oxygen and sulphur in space.

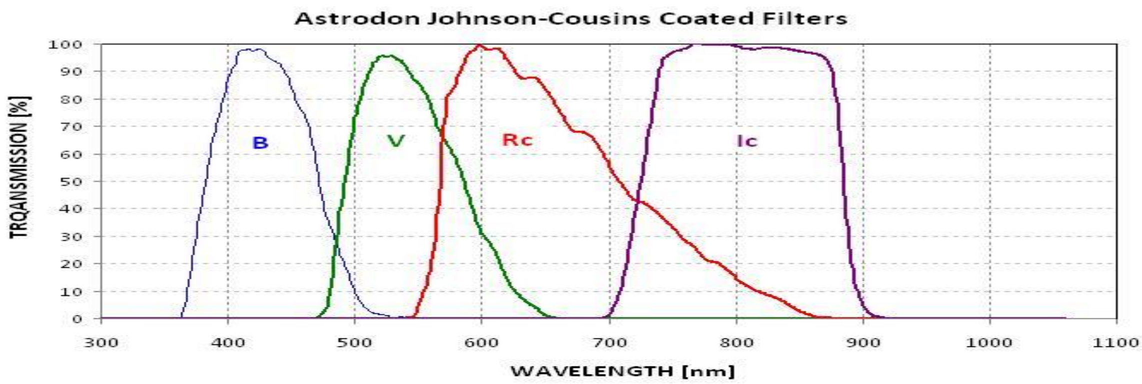
Which of the many results has the right colors or what does the object really look like?

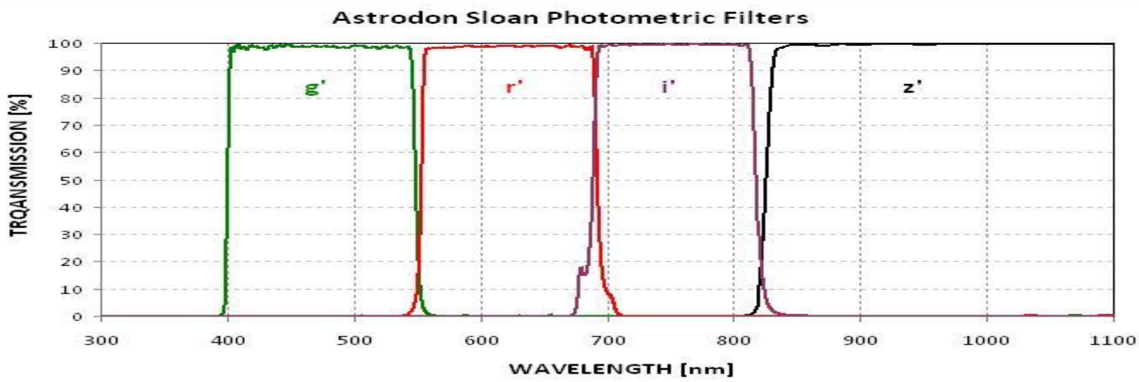
This requires some information about the human eye:





The retina of the human eye contains around 6 million cones, which are responsible for color vision as R, G and B receptors. There are also around 120 million rods, which can only distinguish shades of gray. This means that for every R, G and B color receptor there are 60 B/W receptors, which also have a higher sensitivity. They also do a good job at night, when the color receptors in the eye hardly react or no longer react at all: “All cats are grey at night”, as they say in Germany.
To assess fine structures and details, you should therefore view images literally “in black and white”. If you colorize black and white images, they lose their sharpness and contrast for the human eye.





The question “Which of the many results has the right colors or what does the object really look like?” cannot be answered unambiguously and leads to natural philosophy. A counter question would be “For whom?”.

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Even if we limit ourselves to the human eye, color vision differs from person to person. If you generalize, you have to recognize that an alien, e.g. an intelligent cat or reptile creature, could do little with the coloured images of humans.
Natural science tries to describe nature as independently of humans as possible. Therefore, even when using color filters, black and white images are preferred. Colors are mainly used to highlight different areas: e.g. to separate areas with a high concentration of hydrogen from areas with a high concentration of oxygen.

In classical astronomy, Bessel or Johnson filters were still used, which come very close to the human eye in terms of transmission and absorption. However, these have the disadvantage that 80 to 90 % of the light is only transmitted in a narrow range around the wavelength with maximum transmittance. Outside this range, most of the light is lost, which is not really an option for faint astronomical objects. For this reason, SDSS filters (broadband filters) are increasingly used in astrophysics, which transmit almost all the light (almost 100 %) in a broad band of the spectrum and almost nothing outside it. In addition, the transmission ranges hardly overlap, so that the images can be assigned to specific wavelength ranges that are independent of humans. Any intelligent extraterrestrial would understand this. However, they would possibly prefer the visualization in other colors or perhaps also in tones or .....
One thing is certain: the SDSS broadband filters have little to do with the human eye.

Why are the individual pictures shifted?

Due to the rotation of the earth to the east, the celestial objects appear to move from east to west. The telescope mount must compensate for this movement so that the celestial objects remain in the field of view.
This requires a high degree of precession, especially with the large Faulkes telescopes with a height of around 8 meters and a mass of 25 tons. Even wind and the smallest mechanical defects can contribute to faulty tracking.
Tracking with Alt-Az mounts is a digital and mechanical challenge, especially at the zenith.