TEACHING TRAINING COURSE ON ASTROPHYSICS

- **Lectures Topics**
  - 1 – Evolution of the Stars
  - 2 – Cosmology
  -
- **Workshops Topics**
  - 5 – Solar spectrum and sunspots
  - 6 – Stellar lives
  - 7 – Astronomy beyond the visible
  - 8 – Expansion of the Universe

WS5: Solar Spectrum and Sunspots

Summary
This workshop includes a theoretical approach to the spectrum of sunlight that can be used in high school. The activities are appropriate for primary and secondary levels.
The Sun is the main source of almost all wavelengths of radiation. However, our atmosphere has high absorption of several non-visible wavelengths so we will only consider experiments related to the visible spectrum, which is the part of the spectrum that is present in the daily lives of students. For the activities in non-visible wavelengths, see the corresponding workshop.
First we will present the theoretical background followed by experimental demonstrations of all the concepts developed. These activities are simple experiments that teachers can reproduce in the classroom, introducing topics such as polarization, extinction, blackbody radiation, the continuous spectrum, the emission spectrum, the absorption spectrum (eg sunlight) and Fraunhofer lines.
We also discuss differences between the areas of regular solar output and the emission of sunspots. Additionally, we mention the evidence of solar rotation and how this concept can be used for school projects.

Goals
- To understand what the Sun's spectrum is.
- Understand the spectrum of sunlight.
- Understand what sunspots are.
- Understand the historical significance of sunspots and of Galileo's work on the rotation of the Sun.
- Understand some characteristics of the light such as polarization, dispersion, etc.

List of Materials

Activity 1: Solar Spectrum: Polarization
- 2 polarizing filters (can be parts of glasses)
- polarized glasses

Activity 2: Ligh polarization
- 1 plastic CD cover or piece of glass
- Transparent tape

Activity 3: Solar Structure.
- cuttable
- scissors
- bookbinder

Activity 4: Sunspots and Sun rotation.
- Binoculars (demonstration of how the Sun is observed)
- Real photos of the Sun, acquired over 7 days (Soho)
- Paper, pencil, ruler, calculator, angle protractor, compass

Activity 5: Solar Luminosity

- 2 incandescent lamps, one of 100W and another of 40W
- 2 lampholders
- Plug
- Any kind of rule of one meter
- Transparent oil drops
- Print paper sheet
- Pen, calculator

Activity 6: Opacity
- 1 candle, or tinderbox or lighter or lighter
- Bright light source (retro projector or multimedia projector or LED bulb)
- Screen (can be a cleat wall)

Activity 7: Dispersion of light
- 1 flashlight of cellular
- 1 translucent straight glass, with no drawings on the body or base
- milk drops (can be prepared with milk powder)
- a dropper or equivalent
- ½ liter of water

Activity 8: Dispersion of light in silicon
- 1 silicone stick of hot melt glue
- 1 flashligt of cellular

WS6: Stellar Lives

Summary
To understand the life of the stars it is necessary to understand what they are, how we can find out how far away they are, how they evolve and what are the differences between them. Through simple experiments, it is possible to explain to students the work done by scientists to study the composition of the stars, and also build some simple models.

Goals
This workshop complements the stellar evolution NASE course, presenting various activities and demonstrations centered on understanding stellar evolution. The main goals are to:
-Understand the difference between apparent magnitude and absolute magnitude.
-Understand the Hertzsprung-Russell diagram by making a color-magnitude diagram.
-Understand concepts such as supernova, neutron star, pulsar, and black hole.

List of Materials

Activity 1: Parallax (distances)
- Attendees' fingers
- Background with reference elements
- pencil, paper, calculator

Activity 2: Law of the inverse square of distance (magnitudes)

- 2 squares glued on cardboard of 15cm x 15 cm minimum, in one of them cut out the central square
- Rule
- Flash light

Activity 3: Colors of stars (temperatures)

- 3 flashlights of cellular
- 3 filters R, G and B, stuck on the flash lights (transparent red, green, blue paper)
- 3 black paper cylinders

Activity 4: HR diagram (cumulus ages)

- 1 photo of an open cluster (the kappa Crucis workshop is provided in the workshop)
- 1 grid (is provided) to relate temperature to magnitude.
- Comparative chart of HR diagrams of clusters of different ages (provided)

Activity 5: Supernova explosion simulation (star death)

- 1 basketball ball
- 1 tennis ball

Activity 6: Pulsars (star death)

- 1 flashlight
- 1 rope of at least 1 meter

Activity 7: Black hole simulation (star death)

- 1 piece of fabric or elastic mesh (lycra or similar) of at least 1.5 x 1.5 meters
- 1 tennis ball
- 1 heavy weight spherical object (can be constructed with a balloon full of water)

WS7: Astronomy beyond the visible

Summary

Celestial objects radiate in many wavelengths of the electromagnetic spectrum, but the human eye only distinguishes a very small part: the visible region.

There are ways to demonstrate the existence of these forms of electromagnetic radiation that we do not see through simple experiments. In this presentation, you will be introduced to observations beyond what is observable with a telescope that can be used in a primary or secondary school.

Goals

This activity aims to show certain phenomena beyond what may be observable with amateur telescopes, such as the existence of:

-Celestial bodies that emit electromagnetic energy that our eye cannot detect. Astronomers are interested in these other wavelengths because visible radiation alone does not offer a complete picture of the Universe.
-Visible emissions in the regions of radio waves, infrared, ultraviolet, microwave and X-rays.

List of Materials

Activity 1: Construction of a spectrograph (spectra)
- Template to make the spectrograph (provided)
- 1 CD out of use (or a DVD)
- Common adhesive or paper tape.
- Strong scissor
- Tack (cutter, stylet, scalpel) for fine cutting.
- Glue to be glued (preferably in a bar)

Activity 2: Natural decomposition of light (rainbow)
- 1 hose with diffuser
- a patio or garden

Activity 3: Infrared detection (Herschel)
- 1 large cardboard box (type of sheets for photocopier)
- 1 prism
- 4 laboratory thermometers.
- Common adhesive tape
- clock
- paper, pencil

Activity 4: IR detection with the mobile
- 1 or more remotes with IR LED
- CCD camera of cellular phone (also serves the digital camera)

Activity 5: IR detection through interstellar medium
- 1 flashlight with filament bulb (not led)
- a piece of cloth
- mobile phone camera

Activity 6: Constellation with LEDs
- IR LEDs
- base for installing LEDs
- wire and resistance

Activity 7: Constellations with remote controls
- Several remote controls (depends on the constellation you want to play)

Activity 8: Detection of radio waves.
- 1 9V battery
- 2 wires with peeled tips, 20 cm long

• a radio receiver.

Activity 9: Uses of UV (Black light)
- 1 black light bulb (365nm recommended)
- bills, cards, passports

Activity 10: Filter UV radiation (Black light)
- 1 black light bulb (365nm recommended)
- fluorescent material
- piece of glass or glass goggles
- plastic or organic glasses, tickets

WS8: Expansion of the Universe

Summary
This workshop contains several simple activities to do in which we are going to work with the key concepts of the expanding universe. In the first activity we build a spectroscope to observe spectra of gases. In the second, third, and fourth we experiment qualitatively with the expansion of a rubber band, a balloon, and a surface of points, respectively. In the fifth activity we work quantitatively with the expansion of a surface and even calculate the Hubble constant for this case. In the sixth activity we detect the microwave background radiation.

Goals
- Understand the expansion of the universe.
- Understand that there is not a center of the universe.
- Understand Hubble's Law.
- Understand the meaning of the dark matter and simulate gravitational lens

List of Materials

Activity 1: Doppler effect (redshift)
- 1 rope clock with uniform sound
- 1 cloth bag with handle of at least 50 cm (or a string to attach the clock)

Activity 2: Stretching the photons (microwave background)
- 1 resistive wire of at least one meter

Activity 3: The Universe in a rubber (expansion)
- pieces of 20 cm of elastic of at least 2 cm wide (one piece per 2 students)
- rule of at least 40 cm
- pencil, paper

Activity 4: The Universe in a balloon (expansion)
- birthday balloons (one per student)
- telgopor, isopor (or the appropriate local name) in small spheres (no larger than 5mm in diameter). You can undo a sheet of the same material
- Rubber to paste of any type

Activity 5: Calculation of the Hubble constable (expansion)

- Template with galaxies in a universe before and after the expansion (provided)
- Table to collect data (provided)
- pencil, ruler, calculator

Activity 6: There is no expansion center

- 2 films with points (the image is provided), one copied at 100% and another at 105% and put the 2 sheets on a very well illuminated wall will be enough

Activity 7: Detection of microwave background radiation

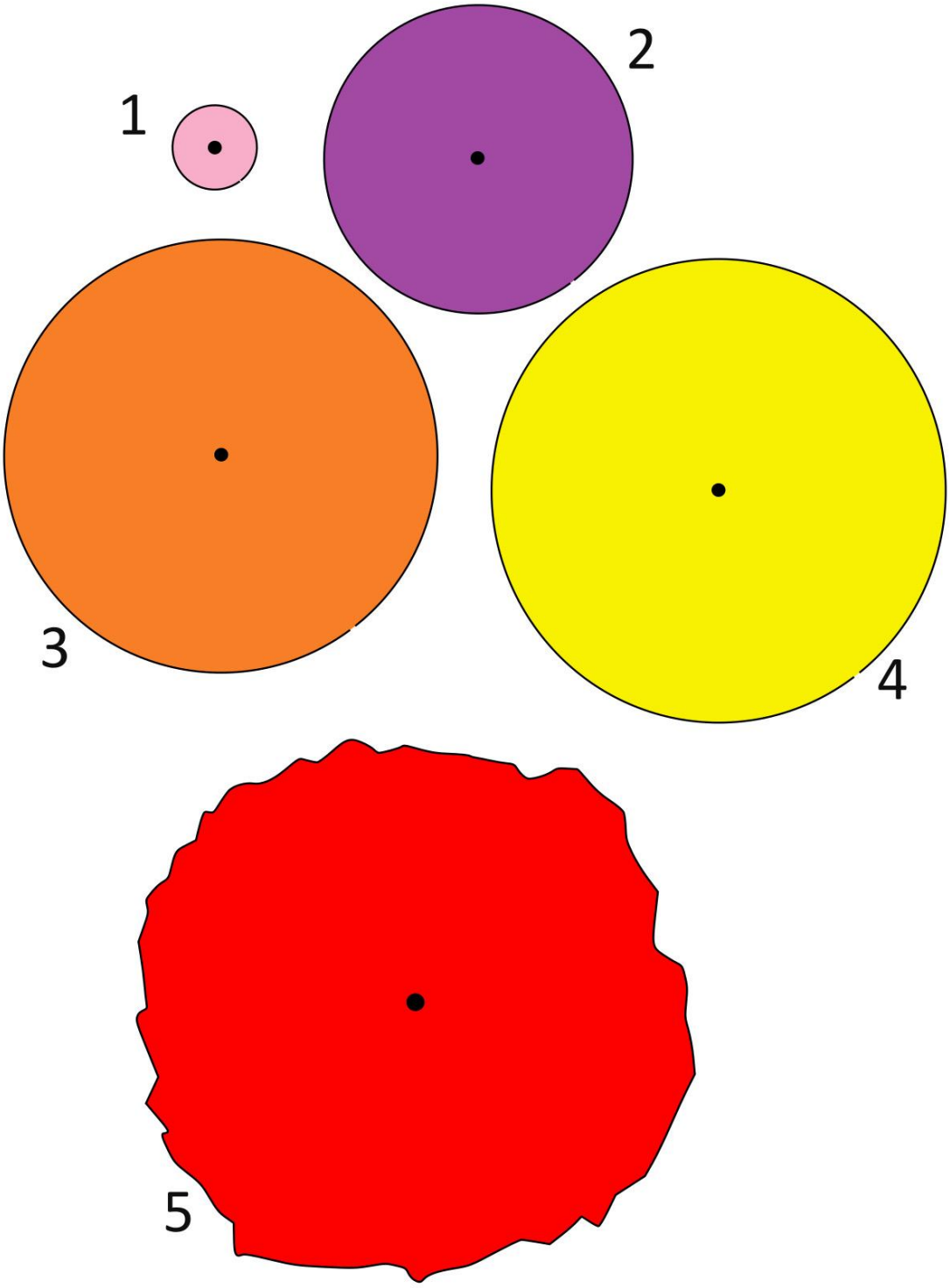
- an analog B & W TV

Activity 8 and 9: Simulation of the deformation of space (dark matter)

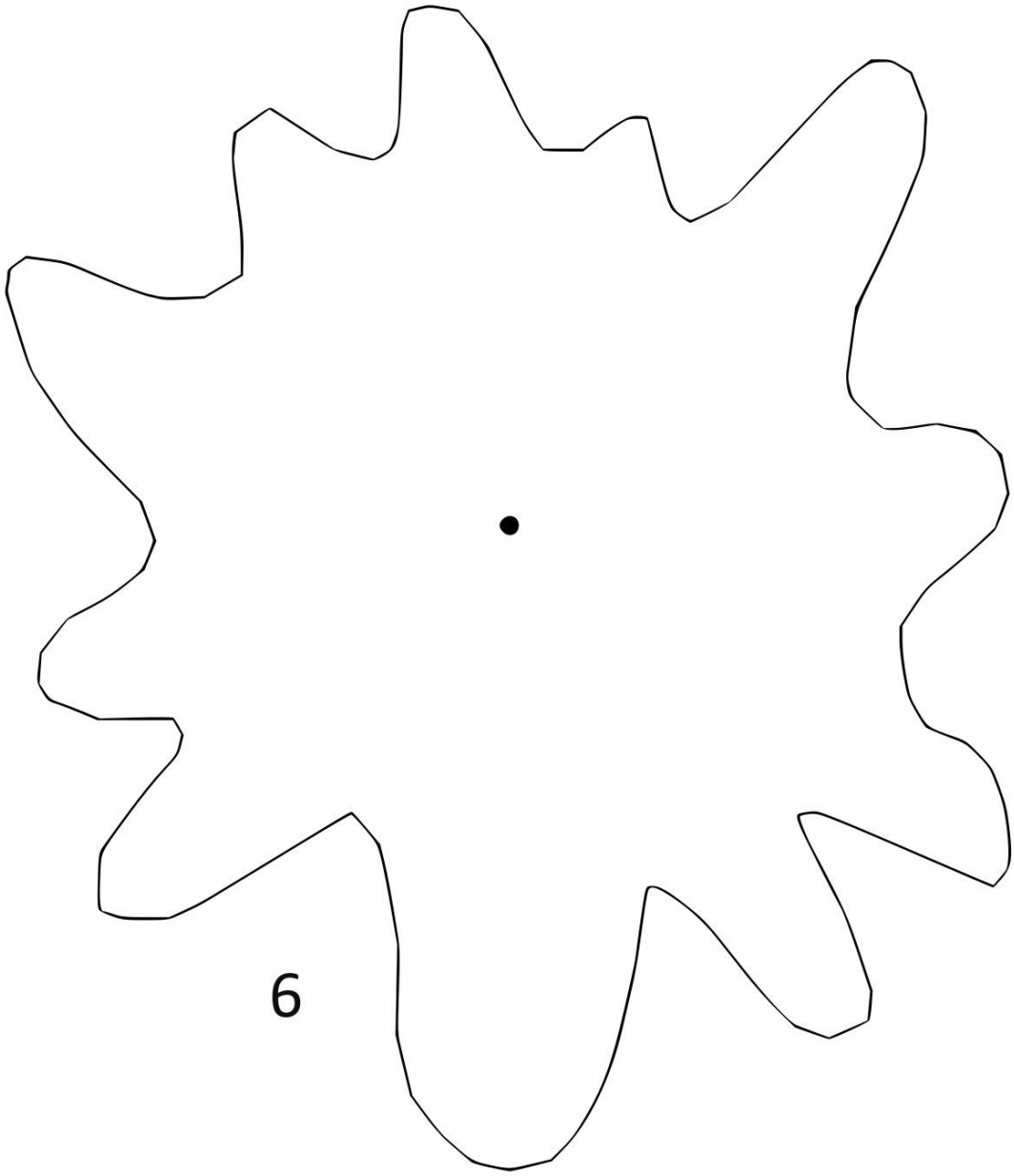
- 1 glass cup of the type used for cognac or water (body bulging in the center) without drawings on the body or base.
- 1 cup foot
- 1 some white wine
- 1 some red wine
- graph paper or graph paper
- 1 flashlight

NOTE: the wine can be replaced by grape juice or other transparent juice, tea, coke.

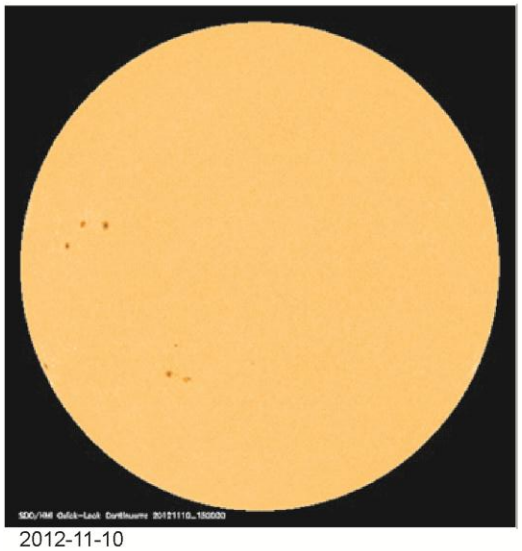
WORKSHOP 5



WORKSHOP 5



WORKSHOP 5



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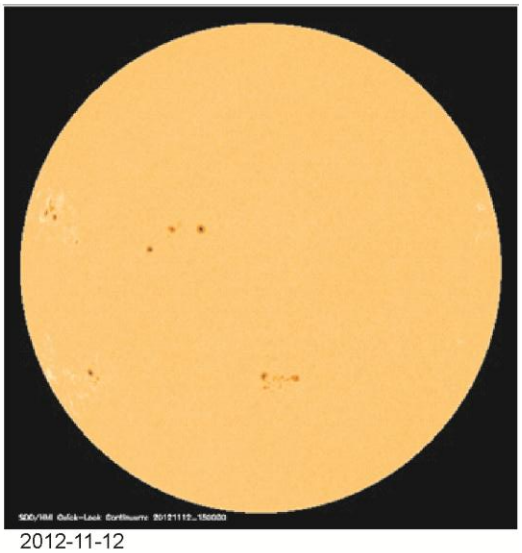

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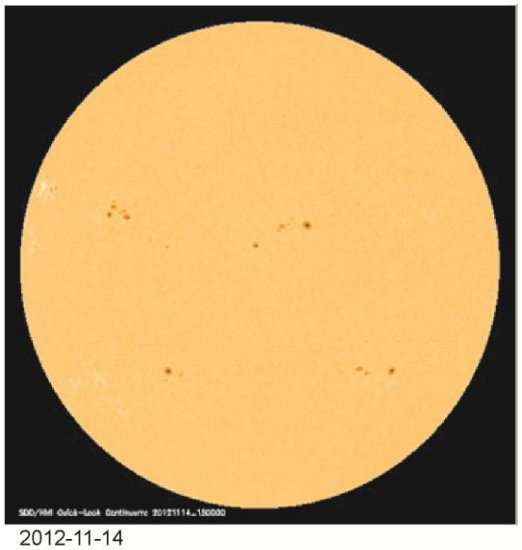

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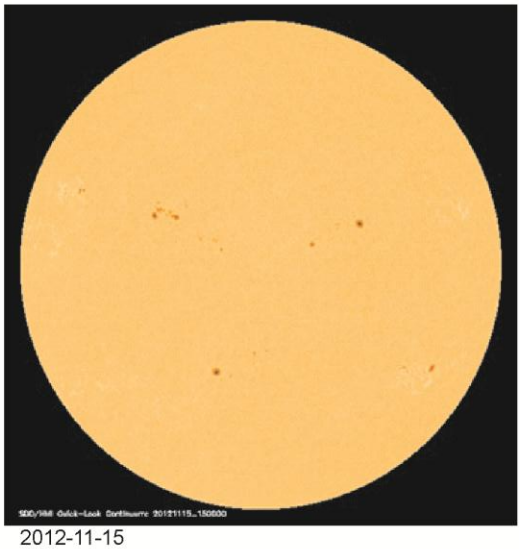

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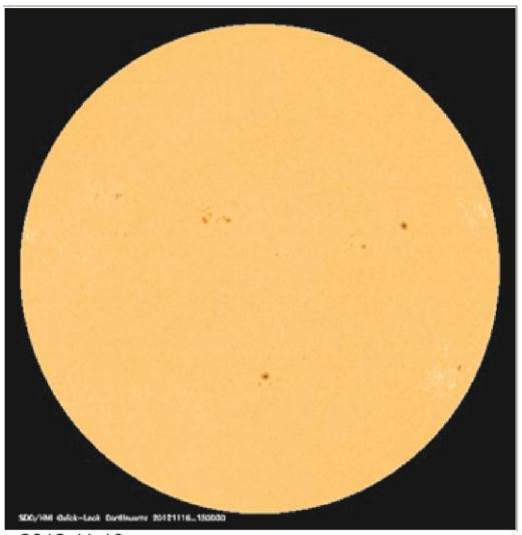

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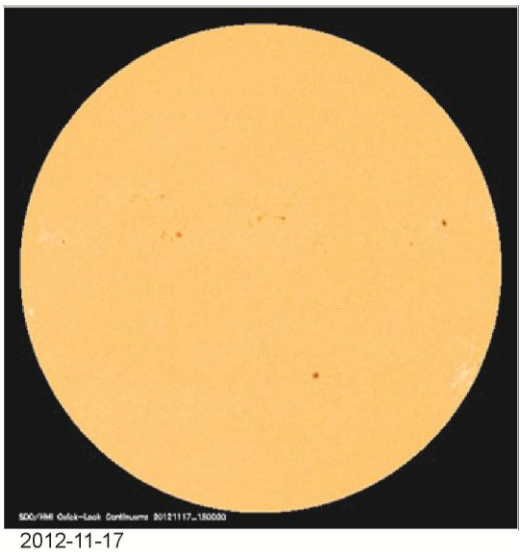

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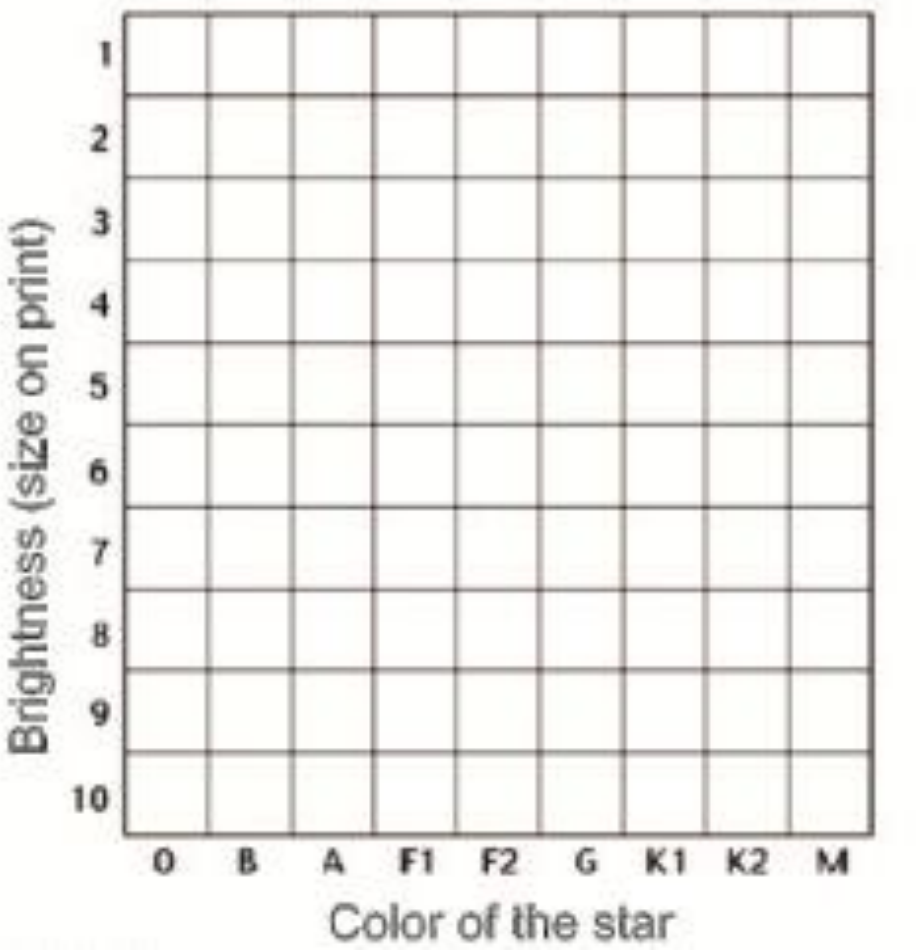
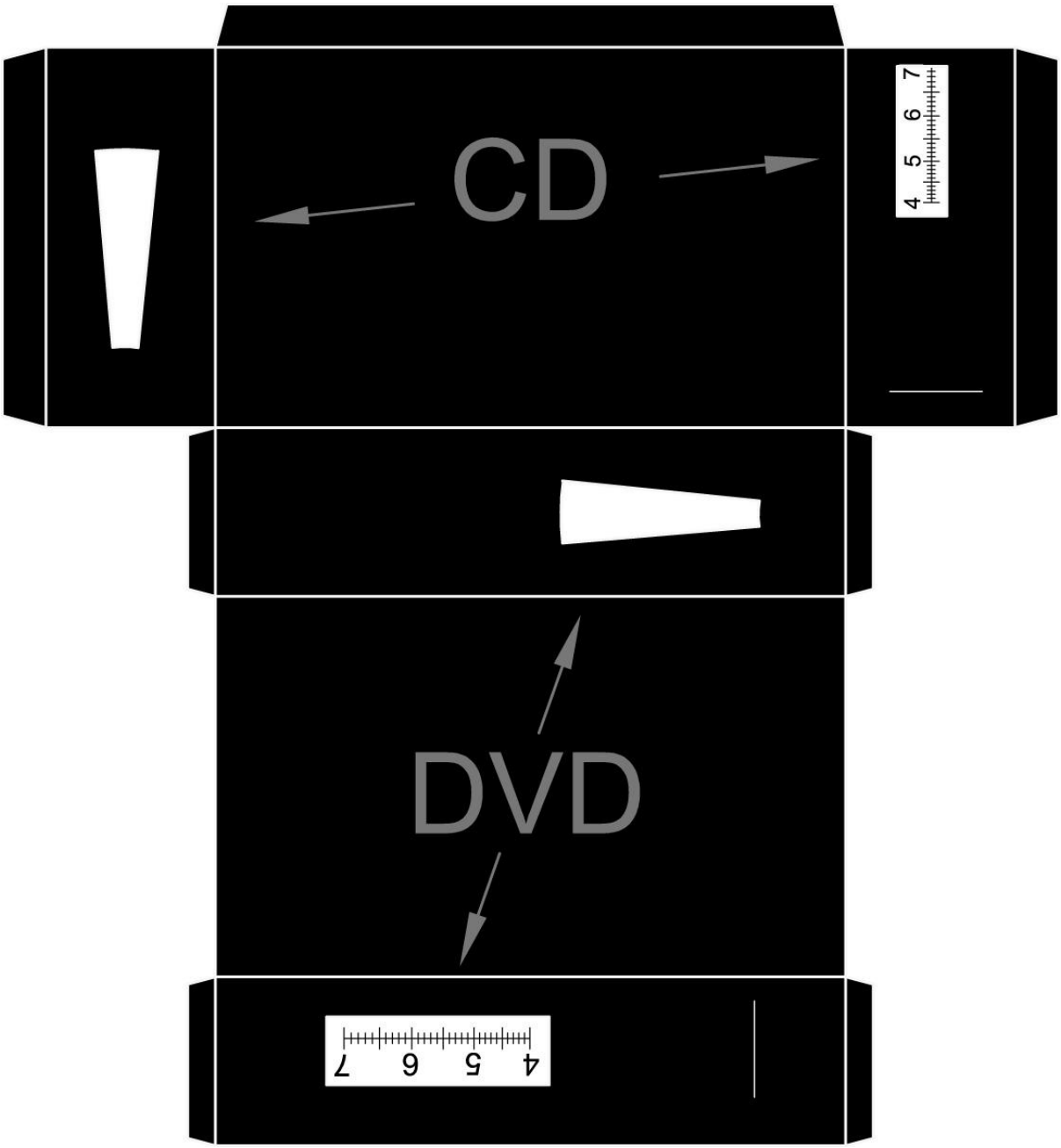
WORKSHOP 6

WORKSHOP 6

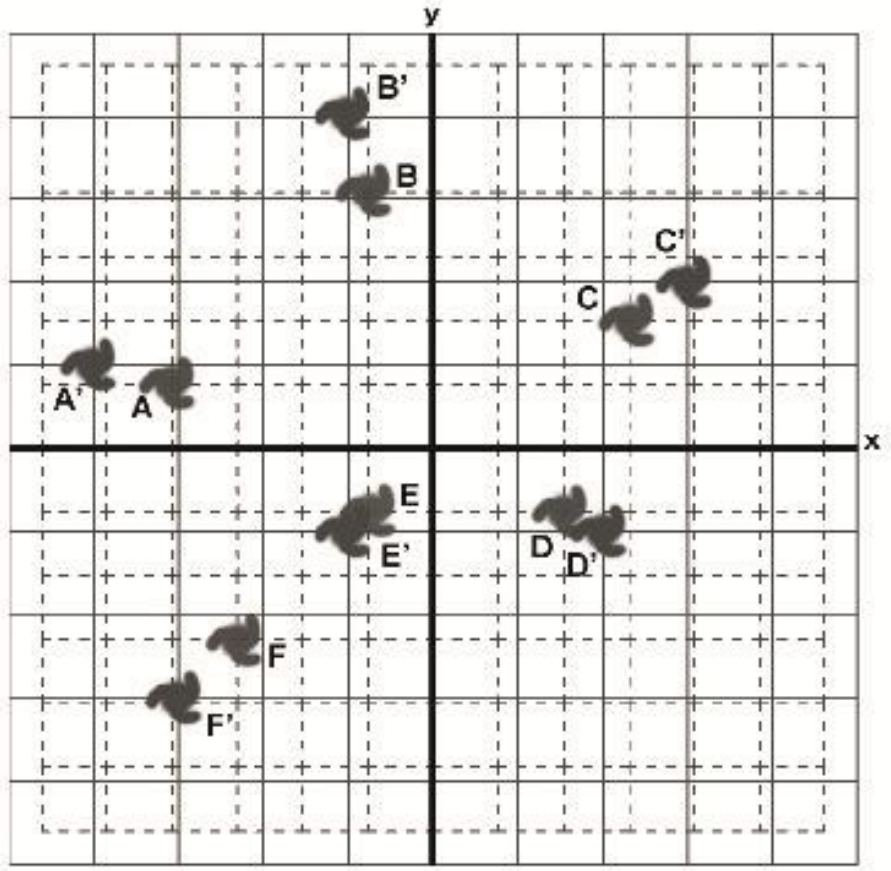

Brightness (size on print)
1
2
3
4
5
6
7
8
9
10
O
B
A
F1
F2
G
K1
K2
M
Color of the star

WORKSHOP 7



WORKSHOP 8

Expansion of the Universe.
Hubble constant determination.



GALAXY	COORDINATES X,Y	D=DISTANCE TO THE ORIGIN	ΔD	$v = \frac{\Delta d}{\Delta t}$	$H = \frac{v}{d}$
A					
A'					
B					
B'					
C					
C'					
D					
D'					
E					
E'					
F					
F'					

WORKSHOP 8