CLASSROOM RESEARCH PROJECT

How can we learn the temperature of stars?

by

Ilya Kovalenko

High school #59,
Astrakhan, Russia

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CLASSROOM RESEARCH PROJECT 2000-2001

Teacher: Ilya Kovalenko
Grade level: 10th
School: High school #59, Astrakhan, Russia
Time line: October, 2000 – April, 2001

Research Problem:
How can we learn the temperature of stars?

The teacher’s goal:

To raise students’ interest
To make students’ mental outlook wider
To form students’ research skills

The teacher’s role:

- Give students list of references on Astronomy and Physics: Starry sky, Optics, Spectroscopy
- Facilitate discussions on the research topic and induce students to make up theoretical ways to achieve the goal.
- Pose questions to find out what equipment we need to make observations: what do we need to make with our own hands
- Organize optional (supplementary) classes and observations
- Encourage students to make conclusions, summarize and present results
- Gathering information about students’ attitude and evaluation of the project

Students’ role:

- Raise their own questions during the research and design ways to answer them
- Use information they gain to solve the problem
- Generating new ideas
- Making up the equipment for observations
- Record and collect the data
- Analysis of the data and making conclusions

CONDUCTING THE RESEARCH

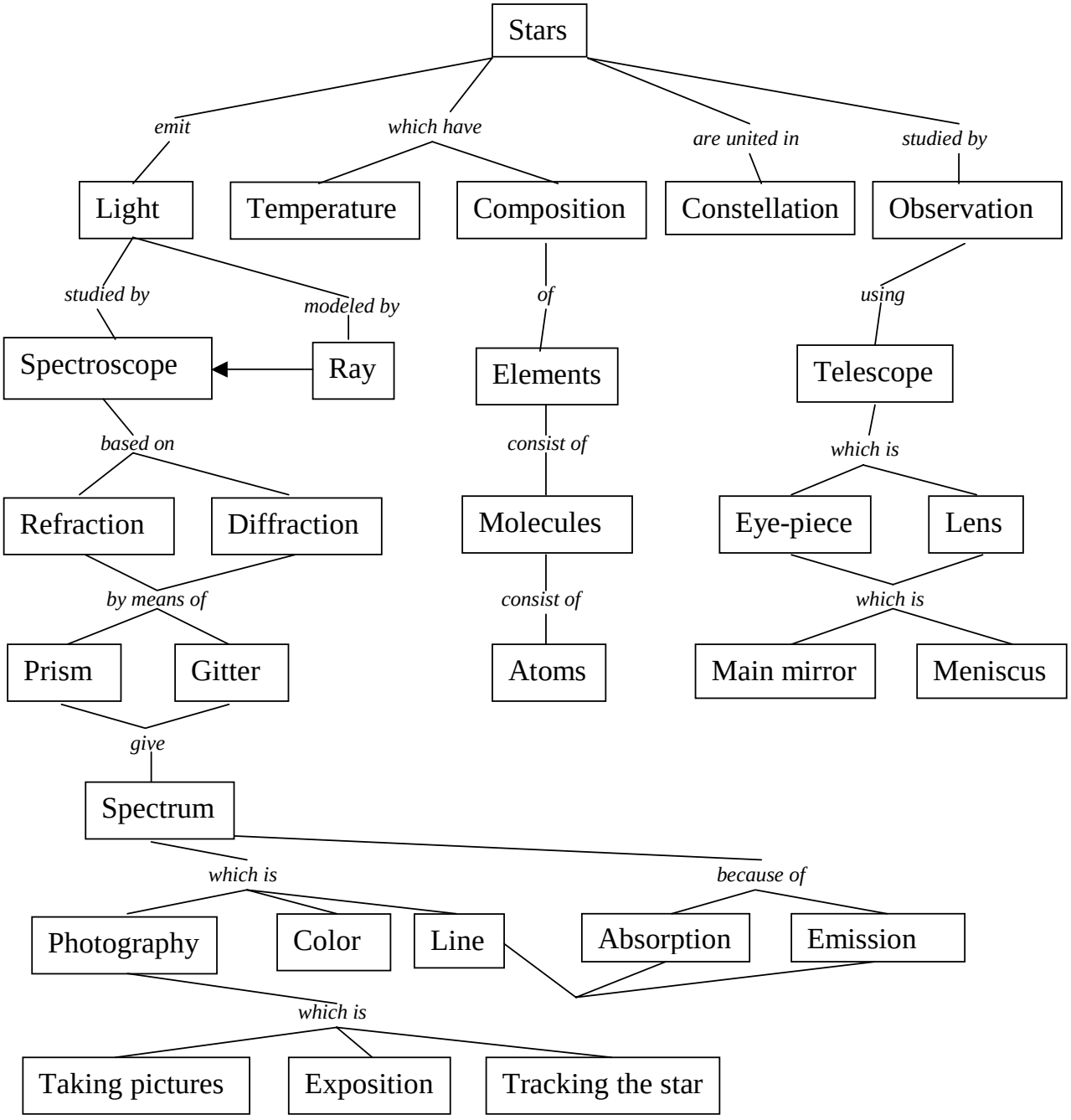
Theoretical part.

Students leaded by the teacher chose the main concepts and established relations between them.

Notions: star, composition, constellation, spectrum, spectroscope, observation, telescope, prism, light, molecules, atoms, photography, exposition, elements, lens, refraction, diffraction, gitter, taking pictures, tracking the star, temperature, absorption, absorption line, main mirror, meniscus

Then we classified the terms and made the concept map:

Concept map


Stars
emit
which have
are united in
studied by
Light
Temperature
Composition
Constellation
Observation
studied by
modeled by
of
using
Spectroscope
Ray
Elements
Telescope
based on
consist of
which is
Refraction
Diffraction
Molecules
Eye-piece
Lens
by means of
consist of
which is
Prism
Gitter
Atoms
Main mirror
Meniscus
give
Spectrum
which is
because of
Photography
Color
Line
Absorption
Emission
which is
Taking pictures
Exposition
Tracking the star

In the process of our research the students used the following theoretical facts (all included in the high school program):

- The laws of geometrical optics: reflection, refraction,
- Undulatory theory of light: dependence of index of refraction on the wavelength of light
- Spectral analysis: decomposition of white light in a prism
- Spectroscopy: dependence of a spectrum on the nature of the emitting or absorbing matter, atomic nature of a spectrum
- Astrophysics: determining the physical properties of sky objects from their spectrums
- Interdependency of the color, temperature and spectrums of stars: spectral classes.

All this theoretical material was studied through several initial lessons, using physics and astronomy textbooks and supplementary literature. The students used this knowledge in their following practical research.

Equipment.

Some words about the equipment we used.

We used:

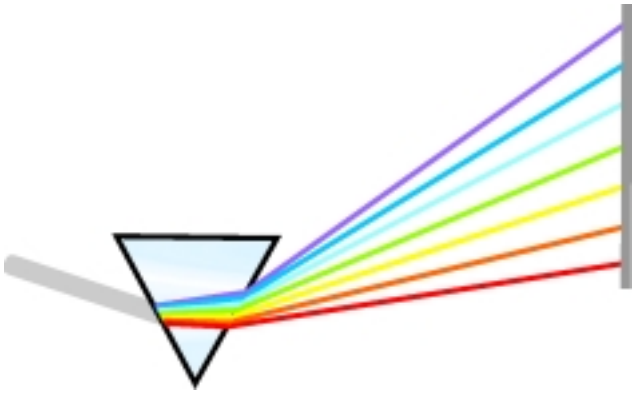
- 15 cm (6 inch) field Maksutov-Kassegren meniscus telescope “Intes”. The telescope played the role of the lens for a camera. The telescope includes a guide for tracking objects and a clockwork. The telescope is portable.
- SLR (single-lens reflex) photo camera “Zenit” to picture the spectrum of a star. We attached the camera instead of the eye-piece.
- Complicated Amici prism from the school spectroscope.
- 1000 speed Kodak film.

The practical part of the research.

We spent some classes studying the telescope, its theoretical principles.

We recall optics. Several times in the evenings we watched the Moon and stars to become familiar with the telescope and the night sky (constellations, stars, planets, nebulas, galaxies, ...).

Every student from my research group studied the spectroscope, the principles of the refraction in the prism, and observed Na^+ spectra. Every student did practical laboratory work, getting the spectrum.

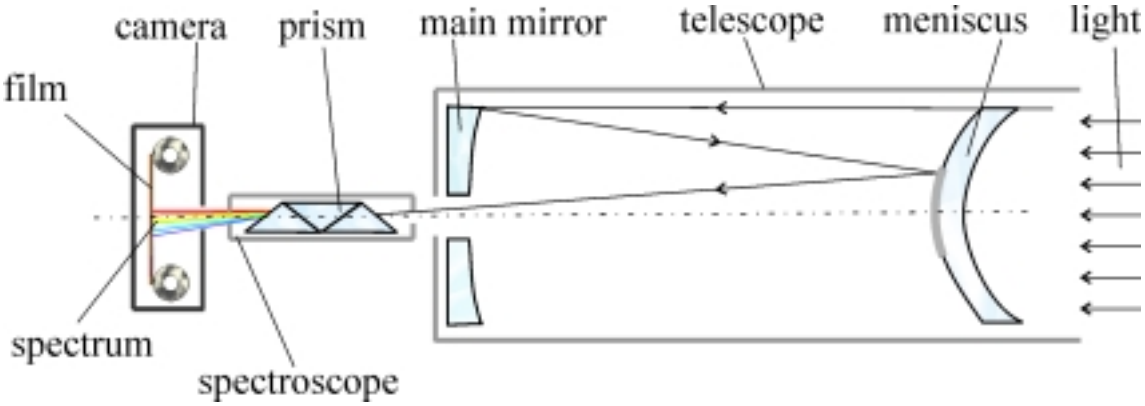


The students studied practical principles of photography making pictures of the Moon, as it is the only object we could picture in the city. The students found and fixed optimal distance from the camera to the telescope to make images sharp and clear, having made series of the moon pictures.

There was a problem: how to get the spectrum? Students discussed different ideas, and finally chose to use a complicated Amici prism from the school spectroscope, because it gave the spectrum in the same direction as the direction of initial light propagation. The prism was in the metal tube, and they with a slot composed the spectroscope itself. The whole spectroscope was a little too big to be used in our experiment.

Amici prism

The students made it suitable for usage in our system, cutting out one edge of the tube where the prism was situated. Then they calculated the distance from the photographic film to the prism, considering the size of the prism (5 mm) and the size of the light beam. They placed the tube with the prism between the telescope and the photocamera. It was possible because the camera was attached to the telescope by means of a broad tube.



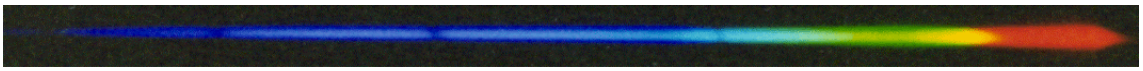
Plant scheme

As our observations lasted for several hours at night, it was necessary to defend optics from dew. The students designed a paper shield for the telescope to prevent condensing of the dew.

Having done all the preliminary work, we came to the main part of our research: we needed the suitable object to picture its spectrum. Some students wanted to choose Sirius, as it is the brightest star, but it

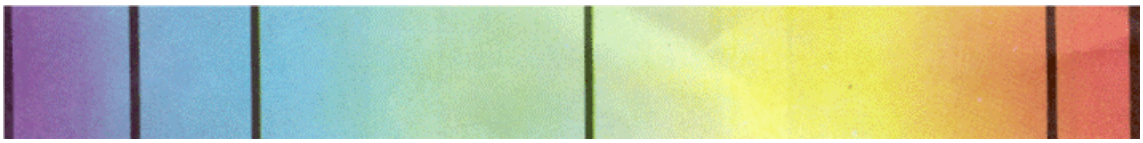
was already invisible in the late spring. Then the students have chosen Vega, because it was seen at night and it is one of the brightest stars in the sky.

The problem was that there was too much light in the city. So we came to the country and spent there the whole night. We took several pictures and some of them were a success. Then in the classroom we examined the pictures and found some lines on them. Finally we have got two independent pictures with the same lines on them.

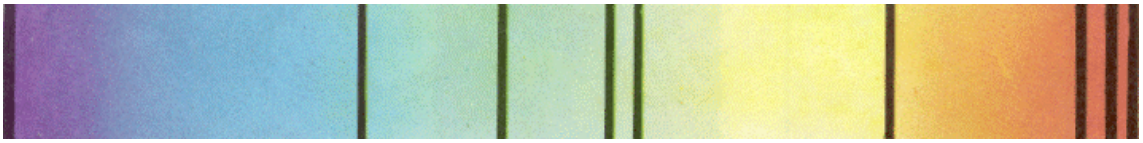


We got two independent spectrums.

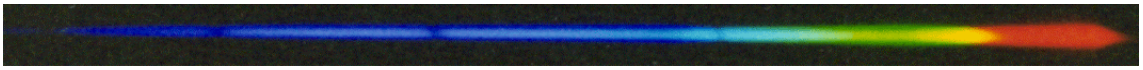
Then the students, according to the plan, compared obtained pictures with spectrums which were shown in the “Encyclopedia for A Young Astronomer”. They found that there were hydrogen lines, but there were no helium lines.



Hydrogen lines



Helium lines



Our spectrum

So they came to the conclusion that Vega belongs to Class A of the classification of star spectrum. Then it was very easy to learn its temperature from the book. It appeared to be about 10000 K. Besides they learned that some other stars belong to the same class and that's why must have similar spectrum. One of the stars is Sirius – the brightest star in the Earth's sky.

I must say my students liked our lessons. They generated an idea to get together for a final sitting. They decorated the walls in the hall with space pictures, brought their own optical apparatuses (binoculars, spyglasses, cameras), and made reports. They read poems, sang songs, and were making plans for the future.

The students raised their own questions:

- what spectral classes do the bright stars of our latitude belong to?
- does the color of the star depend on its spectral class?
- is there any correlation between a variability of a star and its spectral class?
- what spectral class does the Sun belong to?
- do the spectrums of planets differ from the spectrum of the Sun?

The results of their research the students put in the big album. This album already comprises three volumes. It includes information of all student research projects of our high school. Our research group became a member of school scientific society, which was founded 30 years ago. This society is called “Sigma”. It was awarded by a Second Prize Diploma at the Russian Exhibition Center in Moscow some years ago.