

METHODS OF APPLYING VIRTUAL LABORATORY WORK IN TRAINING X-RAY RADIATIONS OF LIGHTS

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<https://doi.org/10.5281/zenodo.10324055>

Abstract. *The article describes the requirements, principles, forms a new generation of modern teaching aids, as well as the order of the training manual for publication.*

Keywords: *modern textbook, consistency, quality, knowledge requirement didactic requirement, succession.*

X-ray and ultraviolet (UV) radiation from celestial bodies arises as a result of the braking of free electrons by external magnetic fields in the vicinity of heavy charged nuclei. This radiation has a coherent spectrum.

The probability of a free electron interacting with a charged atomic nucleus is very high, making this process the primary process that produces hard X-rays and far-ultraviolet (UV) photons.

The deceleration energy of a decelerated electron is emitted in the form of an X-ray photon with an energy (up to 100 keV) corresponding to its distance to the nucleus.

Such X-ray radiation has a spectrum similar to thermal radiation, but it is not strong because it is scattered by an optically thin layer.

X-ray photons can also be produced as a result of the deceleration of fast electrons in a magnetic field, Compton scattering of low-energy photons (for example, light) on relativistic electrons. X-ray radiation generated in such processes is not thermal in nature.

As a result of an electron entering the electron shell (K-shell) closest to the nucleus of heavy atoms, a linear X-ray spectrum is formed, the energy of which is approximately proportional to the square of the atomic number of the nucleus of the element of the heavy atom.

For example, in an oxygen atom, an electron entering the K-shell produces a photon with an energy of 500 eV, and in an iron atom this process produces a photon with an energy of 6.4 keV. Such processes occur, for example, in the conditions of the coronal layers of the Sun.

Strong emission lines of Fe X, Fe XII, Fe XIV, He II ions are observed in the extreme UV spectrum of the solar corona, and strong emission lines of iron hydrogen ions (Fe XXVI) are observed in the X-ray spectrum.

Gamma radiation is a natural extension of X-rays, and there are several mechanisms by which gamma rays are produced.

First of all, as a result of collisions of gas atoms with high-energy protons in the interstellar medium, processes associated with the transition of their nuclei to an awakened state can cause the formation of gamma quanta.

These processes cause the nucleus to return to its normal state and emit gamma rays, the energy of which does not exceed 10 MeV (megaelectronvolt).

When an electron and a positron collide, two gamma quanta with an energy of 0.5 MeV are formed. When cosmic rays collide with atomic nuclei in the interstellar medium, π -mesons.

However, at this moment the π - meson decays into two gamma quanta with an energy of more than 50 MeV. Also, gamma quanta are formed as a result of collisions of high-energy electrons with charged particles, braking of ions in strong magnetic fields.

Wavelength of gamma rays $\lambda < 0,01$ nm, and the energy is more than 0.12 MeV.

Gamma radiation is conventionally divided into four ranges: soft gamma quanta (from 0.1 to 10 MeV), fast (from 10 MeV to 1 GeV (gigaelectronvolt), hard (from 1 to 100 GeV) and transient (100 GeV. Cosmic Gamma rays with an energy of approximately 10^{15} eV (one hundred thousand GeV) were taken.

Gamma rays with an energy of 100 GeV were obtained at the most powerful accelerators.

Thus, X-ray and gamma quanta are formed in the processes of changing the non-thermal properties of space, and their study makes it possible to study the nature of these processes.

X-rays and gamma rays are absorbed by the Earth's atmosphere and therefore do not reach the Earth's surface.

To collect, measure and record these rays, the telescope and measuring instrument must be removed from the Earth's atmosphere.

An instrument that collects and records X-rays and gamma rays is called an X-ray and gamma-ray telescope, respectively. X-rays are also called X-rays.

The first X-ray telescope was based on counting the ions and electrons produced by the impact of X-ray photons on a gas, and was similar to a Geiger counter.

It is a Geiger counter filled with a specially selected gas, such as argon, and a ten-micron thick beryllium foil (similar to thin tissue paper) is drawn into its light hole.

Such a counter can register quanta with an energy of 1.5-6 keV ($\lambda=0.2-0.8$ nm). Two such counters (counting at different ranges) are installed on the GOES-9 satellite currently in Earth orbit and record X-ray radiation (X-ray flares) coming from the Sun.

This satellite also carries instruments to measure the power of the flow of electrons and protons coming from the Sun.

They make it possible to measure proton flux in a wide range (up to 1000 MeV).

While they have high energy resolution, these instruments have low angular resolution, meaning they cannot distinguish between sources of X-ray and gamma-ray flux on the solar surface and measure flux from the entire solar surface as a single source.

The X-ray telescope that creates the image consists of parabolic and hyperbolic mirrors, similar to a reflector.

If we install a bunch of thin tubes or two wire mesh spaced at a certain distance from each other in front of X-ray quantum counters, these devices can also act as a telescope.

Such a device is called a tube and wire collimator and, like a shadow chamber, produces an X-ray image and is used to locate X-ray sources in the sky. The resolution of such a device does not exceed one degree.

The spectrum of powerful cosmic X-ray sources was obtained using a Bregg crystal spectrometer.

This spectrometer consists of a diffraction crystal (such as fluorinated lithium) and a Geiger counter, as well as mechanisms that rotate the crystal and move the detector.

The selected light filter (filter) is placed in front of the input of this device. The fluorinated lithium crystal allows one to obtain a spectrum in the range of 0.13 – 0.31 nm with a spectral resolution of 0.001 nm.

Several thousand X-ray sources have been discovered using high-altitude rockets and X-ray telescopes installed on Earth satellites.

These include various types of exploding variable stars, white dwarfs, X-ray pulsars, exploding X-ray sources (busters) and supernova remnants.

Some sources of X-ray radiation are located outside the Galaxy (for example, X-ray quasars).

Good results are obtained from X-ray telescopes installed on the Earth satellites UXURU, Einstein Observatory, XEAO-2, OSO-7-8, Astron, orbital stations Salyut-4-7, Chandra and others.

X-ray sources are identified by placing the letter X and a serial number after the constellation symbol.

For example, CygX-1 or CygX-2, the first and second X-ray sources in the constellation Cygnus.

Conducting laboratory classes in astronomy using computer technology makes it possible to carry out work (observations and examinations in astronomy, since celestial objects are extremely far from us, and the processes in them occur over very long years) that cannot be performed in laboratory conditions.

Students have the opportunity to review, review, and discuss computer-generated labs at their own convenience. This leads to an increase in the quality of their mastery of the subject.

Study of X-ray sources in the optical and radio ranges. It is possible to study the spectrum of these sources in the optical range and the signals emanating from them in the radio range.

If the Virtual Educational Observatory (VEO) program is not installed on the computer, the program is first installed into the computer's memory. The program is placed in the folder *Program Files* → *CLEA* in the computer's memory.

After that, from the laboratory program *CLEA* → *VIREO*, to enter the first page of *BOO* called *PRODUCTION OF CLEA* from the folder where the program files are collected, select the file *CLEA_VEO*.

In the upper left corner of this page, go to *FileLoginStudent Accounting* and enter up to four student names.

A page called *THE VIRTUAL OBSERVATORY* will then open.

For this lab, the activity chosen will be 7 “The Quest for Objects X.”

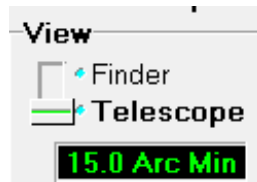
After a while, a *VIREO* exercise page called “*VIREO Exercises The Quest for Objects X*” will open, followed by a smaller page called “Set Date/Time, ID.”, identifier). We confirm this action with the “OK” button.

A new page will now open with the *Telescope* → *Optical and Radio* contexts. This means that this work should be carried out in the optical and radio ranges.

For the optical range, we select “Access 4.0 Meter” since these sources are usually dim. A page similar to the one used to obtain the spectrum of the star will open. The difference between this page is that in the lower right part of the “*Telescope Control Panel*” there are “*Optical off*” and “*Radio off*” buttons.

After confirming the “Optical off” button, go to the “*VIREO Optical Telescope Control*” page. On this page, using the “Tracking” button, the telescope is placed on the clock mechanism.

In the “*View*” area in the upper right corner of the starry sky area, switch the button from “*Finder*” to (telescope).



A list of 16 X-ray sources, called the “Object X Observation Hot list,” will open through the Slew → Observation Hot List → View/Select from List contexts in the upper left corner of the page (Figure 1).

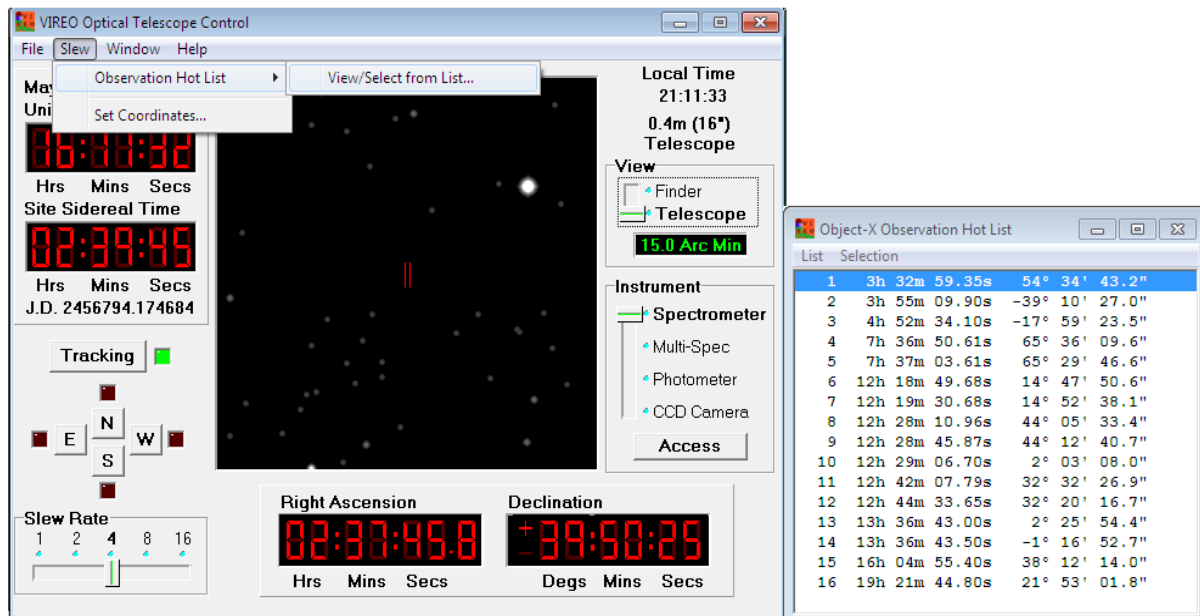


Figure 1. Opening a list of X-ray sources.

This resource is selected from this list and marked, and a page with the coordinates of this resource opens on the screen. If the OK button is confirmed, the telescope will begin searching for this source.

A source with given coordinates is inserted into the input slot of the spectrograph installed in the telescope. Using the “Access” button in the lower right corner of the page, the source spectrum recording page opens.

You can expand the spectral range using the File → Preferences context in the upper left corner of this page (Fig. 2).

Some X-ray sources have an optical spectrum consisting of a continuum, while others have a continuous spectrum with emission lines. The radio emission from these sources consists of pulses.

If both optical and radio telescope are selected on the next page of the main page, then the “Optical off” and “Radio off” buttons will appear in the lower right corner of the next page, under the “Telescope Control Panel” and “turn off the radio”), which means it is possible to study the selected source in the optical and radio range.

For this purpose, Telescopes (Teleskoplar) → Optical → Access 4.0 Merter va → Radio (telescopes → optical → access 4.0 meter and → radio) are marked (Fig. 3).

First, the spectrum of the source is obtained in an optical telescope. To do this, “Optical off” is activated. A new page opens on the screen, on which we connect the clock mechanism to the telescope using the “Tracking” button on the left side of the starry sky, and launch the spectrometer recording the spectrum using the “Access” button (Fig. 3).

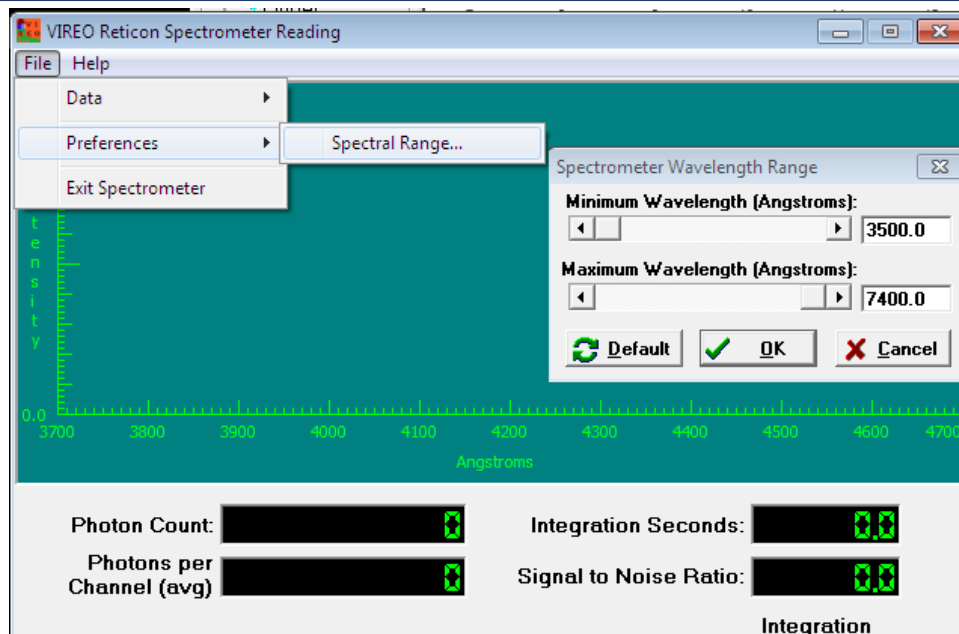


Figure 2. Spectral range expansion.

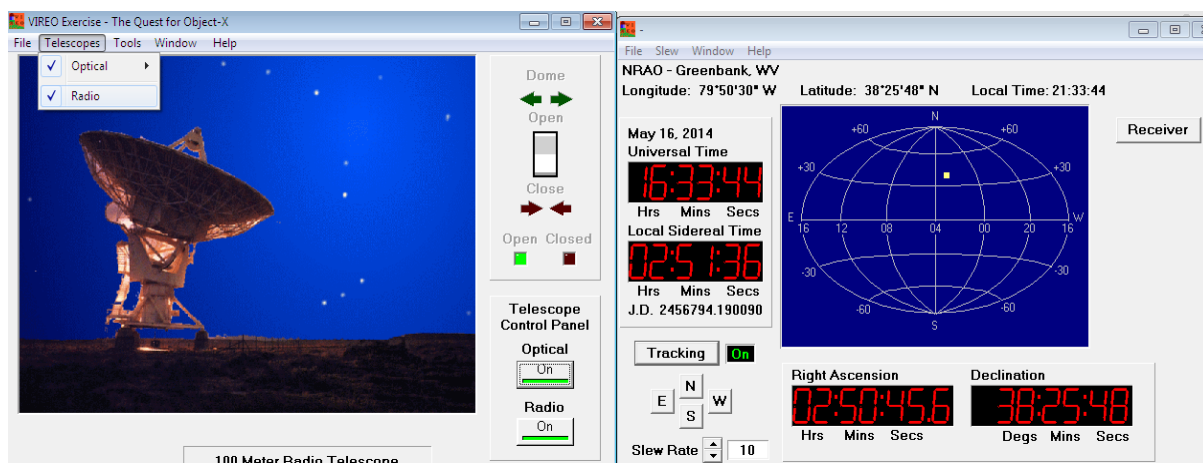


Figure 3. Preparing a program to work on both optical and radio telescopes simultaneously

It will be correct if the spectral range is expanded, then confirm the “Go” button and start the spectrometer. After storing the optical spectrum of the source, its radio signals are recorded. To do this, the “Radio off” button in the lower right corner of the main page is activated and a radio telescope appears on the screen. The “Tracking” button is activated, and the “Receiver” button activates the recording of radio signals (Fig. 4).

If the “Mode” and “Record” buttons are activated on this page, radio signals coming from the X-ray source will begin to be recorded and stored in the computer’s memory.

After 20 seconds of recording, the countdown is stopped with the “Mode” button. The stored radio recording and optical spectrum are analyzed and a conclusion is drawn about the source. It analyzes the properties of the source's optical spectrum and the properties of the source's radio signal.

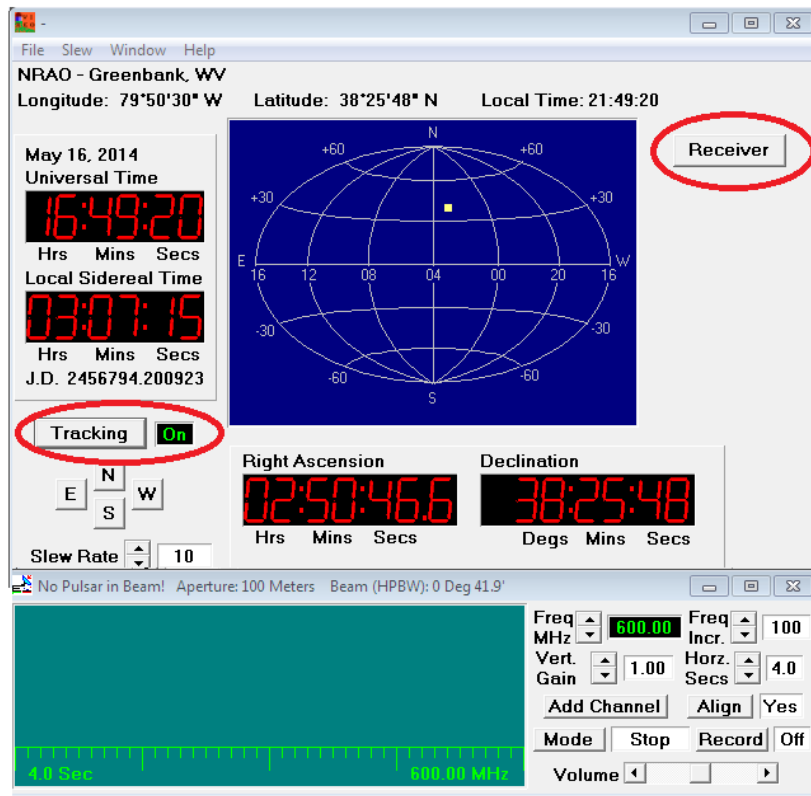


Figure 4. Starting up the receiver that records radio signals.

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3. vireo-the-virtual-educational-observator4.software.informer. CLEA - Современные лабораторные работы по астрономии (Contemporol Laboratory Exercise on Astronomy) и VIREO - Виртуальная образовательная обсерватория (Virtual Educational Observatory)