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Methodology For Processing Images From Optical Observations And Photometry In Astronomy Course Laboratory Workshops

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Abstract: *In this work, a methodology for processing and photometry of images obtained from optical observations in laboratory classes of the astronomy course was developed. The main goal of the work is to correctly calibrate the data obtained from the observation processes, reduce noise, and determine the physical properties of astronomical objects using photometry. During the image processing, bias, dark, and flat field calibrations were performed. Using photometry, the brightness and color indices of objects were determined, and the classification and evolutionary state of stars were studied. During the work, modern software was used to increase the accuracy and reliability of observation results. This methodology is intended for practical application in astronomy laboratory classes and serves to develop the skills of students and researchers in analyzing observational data.*
Key words: *Astronomy, Optical observations. Image processing, Photometry, Physical properties of stars, Calibration, Color index, CCD cameras, Modern software, Analysis of observational data.*

One of the main goals of astronomy is to study the structure, motion, and evolution of objects in the universe. In this process, analysis of data collected through observations is of great importance. In particular, optical observations serve to determine the physical properties of stars, planets, galaxies, and other objects, and to understand their dynamics.

Today, with the help of modern telescopes and CCD cameras, it is possible to collect accurate data on the brightness, color indices, and other parameters of astronomical objects. Processing and analysis of this data is carried out using digital technologies. Correct processing and photometry of the results of optical

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observations helps to determine important parameters of objects, such as the class, temperature, mass, and chemical composition of stars.

The main task of these laboratory exercises is to develop a methodology for processing and photometry of images obtained from optical observations. This methodology serves not only to determine the physical properties of stars, but also to develop skills in analyzing observation data in digital format.

In the process of processing the observation results, noise reduction, image calibration, and automatic object detection are important stages. The brightness and color indices obtained by photometry allow us to determine the location and evolutionary stage of stars in the HR diagram.

Therefore, the relevance of this work is manifested not only in deepening the theoretical foundations of astronomy, but also in mastering practical observation methods. Modern software tools and digital processing methods serve to increase the efficiency of this process.

During the research of this dissertation, an attempt will be made to answer the following questions:

• How are the main stages of processing images obtained from optical observations carried out?

• How can the physical properties of objects be determined using photometry?

• How do the results obtained contribute to understanding the place of stars or other objects in the universe?

This study is of great theoretical and practical importance in astronomy education and research activities, and gives a new direction to the development of methodologies used in laboratory exercises.

The processes of processing and photometry of images obtained from optical observations in astronomy laboratories play a key role in determining the brightness, color, and other properties of stars. Below is a step-by-step methodology for this process.

1. Image Processing

Image processing involves cleaning and calibrating the raw data obtained during the observation process.

1.1. Initial data collection

- **Optical surveillance equipment:**

Telescope and camera (CCD camera preferred).

- **Image type:**

Object images (basic observation data).

Calibration images:

- **Bias frames:** To detect signals coming from the CCD camera itself.
- **Dark frames:** To measure noise.
- **Flat field ramkalar**: To smooth the light distribution in object images.

1.2. Image calibration

1. **Bias correction:** Subtracting bias frames from object images.
2. **Dark correction:** Eliminate thermal noise using dark frames.
3. **Flat field correction:** Smooth out uneven lighting in images.

1.3. Combining images

Combining multiple images of the same object:

- Using the stacking method to improve the signal-to-noise ratio.
- Software: AstroImageJ, IRAF, or MaxIm DL.

2. Photometry Process

Photometry is the process of accurately measuring the brightness of objects.

2.1. Types of photometry

1. **Aperture photometry:**
   - Measuring the brightness within a region (aperture) of an object in an image.
   - Determining the overall brightness, taking into account the brightness of the background.
2. **PSF (Point Spread Function) photometry:**
   - Create a model of a star's image and determine its brightness.
   - Used for very dense objects.

2.2. Photometry steps

1. **Identifying and centering stars:**
   - Identify objects using software (e.g. AstroImageJ, DAOPHOT).
   - Determine the center coordinates of each star.
2. **Aperture selection:**
   - Setting the optimal aperture (usually a radius slightly larger than the object size).
   - Separate calculation of background brightness.
3. **Brightness calculation:**
   - Separate brightness according to the subject and background.
4. **Calibration:**

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Calculating magnitude using standard stellar data: m=−2.5log(F)+Cm = -2.5 \log(F) + Cm=−2.5log(F)+C where FFF is the measured brightness of the object, CCC is the calibration constant.

2.3. Color index determination

To determine the color index, the difference in brightness measured through different filters is calculated:

B−V,V−R (to determine the type of stars) B - V, V - R \quad \text{(to determine the type of stars)} B−V,V−R (to determine the type of stars).

3. Software Recommendations

The following programs can be used for image processing and photometry:

1. AstroImageJ: Convenient for photometry and image processing.
2. IRAF: Powerful tool for professional astronomers.
3. MaxIm DL: For image processing and calibration.
4. Python libraries:
5. Astropy: Astronomical data processing.
6. Photutils: Automate photometry processes.

4. Visualization of Results

Representation of images and measurements in graphical form:

- Magnitude diagram: Relationship between magnitude and time (light curves).
- Color-magnitude diagram (HR diagram): Identification of star types based on color indices.

5. Report Preparation

The report on the photometry results is structured as follows:

1. Introduction: Description of the images and observation methods.
2. Methodology: Processing and photometry steps.
3. Results: Magnitudes, color indices and diagrams.
4. Conclusion: Physical interpretation of the objects (mass, temperature, evolutionary stage).

As part of this work, a methodology for processing and photometry of images obtained from optical observations for astronomy laboratory exercises was developed. This methodology includes calibrating raw images obtained from the observation process, reducing noise, and determining the physical properties of stars.

Photometric methods were used to measure the brightness, color indices, and other parameters of the objects. During image processing, data quality was improved using calibration frames (bias, dark, and flat field). The data obtained allowed the class, temperature, and other physical properties of the stars to be determined, and their evolutionary state was shown on the HR diagram.

The research results show the following:

1. Correct processing of optical observation results significantly increases the quality of observations.

2. Photometry allows accurate and reliable determination of the physical properties of stars.

3. The use of modern software allows for automation and increased efficiency of the observation data processing process.

The scientific and practical significance of this work is that the developed methodology allows enriching laboratory exercises in astronomy education, developing students' research skills, and effectively analyzing astronomical objects. In the future, research can be continued within the framework of this methodology in the areas of analyzing high-resolution images, working with large databases, and improving algorithms.

This work makes a small contribution to the science of astronomy and serves to improve observational processes.

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