EURO-ASIAN

ASTRONOMICAL SOCIETY

V International Astronomy Olympiad

20 - 27. 10. 2000. **SAO RAS, Nizhnij Arkhyz**

Theoretical round. Problems to solve

Group A.

1.
As you know, the most widely used calendar in the middle centuries was Julian. Just now most countries use the Gregorian calendar and the difference between Julian and Gregorian calendars is 13 days: for the same days dates in the Julian calendar fall behind the dates in the Gregorian calendar by 13. Last time the dates in these calendars coincided were in the 3rd century.
Calculate in what century such a difference will be 1 year and the 22nd of October (for example) in Gregorian calendar will coincide with the 22nd of October in the Julian once again.

2.
Two stars have the same apparent magnitude and are of the same spectral type. One is twice as far away as the other. What is the relative size of the two stars?

Group B.

1.
A quasar is observed and it is found that a line whose rest wavelenght is 3000 A^o is observed at 15000 A^o. Estimate:

a) How fast is the quasar receding?
b) How far away is it if its distance is given by the Hubble relation (The Hubble constant is H = 75 km/s/Mpc)?
Both answers may be done with an accuracy of 30 %.

2.
Young scientists from the Komi-Republic territory (in the Russian Federation) registered a few days ago a new object looking like an eclipsing binary star. But the period of this star was not stable: the stellar magnitude of the object is usually equal to 24.32^m. Once every 7-11 seconds it is rising to 24.52^m for 0.2-0.3 seconds. After investigations it was clear that the shining object is eyes of a group of absolutely black cats sitting on a small absolutely black body in our Solar System and looking towards the Sun! And one of the cats is blinking! Calculate the number of cats in the group sitting on the small body and looking to the Sun. Draw a picture explaining your solution. Consider that all the cats are equal in size.

Groups A and B.

3.

There are two photos of the Moon taken by the same camera mounted on the same telescope (the telescope is placed on the Earth). The first photo has been made while the Moon was near its perigee and the second one – near the apogee. Find from these data the value of the Moon's orbit eccentricity. Estimate the minimal period between the moments at which these two photos could be taken.

4.

A cosmonaut in a spacecraft is moving over the Moon surface through the Mare Frigoris at an altitude of 100 km. An astronaut is walking on the Moon's surface at Mare Frigoris and it is daytime at that place (the Sun is shining). Can the cosmonaut register the astronaut using binoculars with a magnification of 20^x. Take into account all the possibilities.

5.

There is a radio source placed on a satellite of some planet named "Olympia". The radio source is working all the time but an observer does not register the signal all the time due to eclipses. The figure shows the level of the receiving signal by the observer vs time. Find from these data the average density of the planet. Take into account that the orbit of the satellite is circular, the observer is in the plane of the satellite's orbit and "Olympia" is far away from the observer.

6.

An 1.2-meter Schmidt camera has a 6° × 6° field of view. Estimate how many photographs you would have to take to cover the whole sky. (Please, make an estimation of the maximum and minimum number of photos.) Explain your calculations. Where do you have to place your telescope to be able to do this?

Practical round. Problem 1 to solve

Groups A and B.

A SUPERNOVA IN THE GALAXY NGC 3184.

Sorry, figures are not ready.

Introduction:

Special Astrophysical Observatory of Russian Academy of Sciences participates in an international program on investigation of supernovas bursting in distant galaxies. Stellar magnitudes of supernovas are measured with the help of CCD at 1-meter and 60-centimeter telescopes. For the brightest of galaxies the spectra are also obtained.
Fig.1 presents a recent sample of a CCD image obtained with the 60-centimeter telescope. It was taken on October 7, 2000. It shows a part of a galaxy cluster, in one of which a supernova burst. Galaxies are marked with the letter G. Their images differ from sharp images of stars by fuzzy edges. The visible stellar magnitudes of two brightest galaxies and the supernova (it is marked with the letters SN) are indicated.

And now the task itself:

In Fig.2 is shown an image of a spiral galaxy NGC 3184 in which on December 10, 1999 a supernova was noticed. The image was taken before the burst! You can see stars up to 23rd magnitude in it.
Fig.3 is a CCD image with a part of the galaxy and the supernova taken on January 28, 2000 with the 1-meter telescope of SAO.
Galaxy NGC 3184 is in the constellation of Ursa Major. Its coordinates (1950) are as follows: $\alpha = 10^{h}\ 15^{m}$, $\delta = 41°\ 40'$. It is similar to the famous galaxy of M33 in the Triangle (M33 is closer to us, the distance to it is 700 kpc, its angular size is about 50′).
By the images of 28.01.2000 in SAO the apparent stellar magnitudes of the supernova in blue, green and red filters were determined. Its apparent stellar magnitude was $14^{m}.67$.
Find the supernova in Fig.3.
Estimate its absolute magnitude.
Professional astronomers don't doubt that they deal with a supernova. In particular, a spectrum was obtained, by which it was assigned to type II. But nevertheless – for non-professionals – prove that it is not a burst of a nearby (foreground)-star on the background of a galaxy.

Practical round. Problem 2 to solve

Group A.

A "DRILLING" OF THE MOON WITH THE HELP OF RATAN

Sorry, figures are not ready.

Introduction:

Dear students, you are to see the first colonies on the Moon. The areas of the Moon surface consisting of oxygen-bearing rock are already being searched for them. First of all these are ilmenite basalts. Beside oxygen (10% from the weight) the ilmenite ($FeTiO_3$) can give a pure iron.
With the help of the radio telescope RATAN-600 a "radio drilling" of the Moon was carried out: unlike the visible light, radio waves come from under its surface. The depth of the "drilling" increases with the increase of wavelength. At the wavelength of 1 cm the Moon is transparent down to 0.5 m, at 30 cm – down to 10 m. The regions with increased content of ilmenite are also distinguished by an increased radio emission level.
Fig.1 presents radio cuts of the Moon obtained at its passage through the "knife" beams of RATAN. From the 6 used wave lengths only 3 are presented, since the cut at 2.1 cm almost repeats the cut at 1.4 cm, and the cuts at 3.9 and 31 cm differ little from the cut at 8.2 cm. The last could be said also about 13-cm cut, but at the moment of observation the transmitters left at the Moon by American astronauts were operating, exactly at this wavelength.
The cuts at different wavelengths can be compared both to each other and to the seas and continents known to you in the image of the Moon in visible light. A band covered in the observations at 1.4 cm is marked in it. In other wavelengths the beams cover the entire disk of the Moon in altitude. The positions of transmitters operating at the wavelength of 13 cm are also shown.

Task:

What transmitters were operating at the moment of observation?
What is the difference in the image of the Moon in cm wavelength from its image in visible wavelengths? What is the reason for it?
What region would you recommend for the settlement of first colonies?

Practical round. Problem 2 to solve

Group B.

SPECTRA OF A PLANETARY NEBULA "CAT EYE" AND ITS CENTRAL STAR

Sorry, figures are not ready.

Introduction:

Planetary nebula NGC 6543 ("Cat eye") played its special part in the history of astrophysics. On August 16, 1865, an English amateur astronomer William Heggins looked at it with a spectroscope and, as he writes, "did not see an expected total spectrum, but only one bright line!" Shortly after it was resolved into two lines with the wavelengths of 4959 å and 5007 å. Heggins assigned it to a new element "nebulium".
Later it was found out that these are "forbidden" lines of doubly ionized oxygen that were never observed before - neither in terrestrial laboratory nor in stars. Unlike "permitted" lines, only a very thin gas emits such lines.
Recall that if an atom is neutral, then a Roman numeral I follows the symbol of its chemical element, if the atom lost one electron then it is Roman II, etc…. for example, the neutral nitrogen is N I, the ionized nitrogen is N II. In notation of forbidden line the symbols of atoms and ions are taken in square brackets, for example: the ionized nitrogen is [N II], doubly ionized oxygen is [O III].
The spectrum of the central star generating the nebula NGC 6543 and exciting its glow, as well as the spectrum of the nebula itself were obtained in the course of study of the late stages of stellar evolution. The high-resolution spectrograph of the 6-meter telescope of SAO was used. The star and a peripheral part of the nebula were alternately projected onto its slit. These positions of the slit marked by a sign ' * ' for the first one and by a sign ' @ ' for the second one in Fig 1a, 1b, 1c.

Task:

The upper parts of Fig. 1a, 1b, 1c show the parts of spectra as intensity vs wavelength given from the mentioned regions. In each of them the interesting lines are selected, and their profiles of are presented in the lower fragments as a relation between intensity and radial velocity. The figures show also the values of radial velocities measured by the tops of profiles of separate lines.
Determine which lines belong to the star and which to the nebula; fill in the appended table:

Lines in the spectra of NGC 6543 and its central star:

Figure	Lines belonging to the nebula	Lines belonging to the star
2a		
2b		
2c		

What is the difference between them?
What can be said about the character of motion in the nebula and in the star's atmosphere from the form of the line profiles?
Estimate the velocity of these motions.

Observational round (the day's part). Problem to solve

Group A.

STARS ON THE DAYTIME SKY

Introduction:

You cannot see stars at daytime with a naked eye. And can they be seen with a telescope? If yes, explain why? Write here your explanation:

You have an opportunity to test that with the help of a guide of 1-meter telescope of SAO. Its objective-glass diameter is 20 cm, focus distance is 3 m, and field of seeing is 21´.

Preparation to observation.

Using the map of stars, select a star.
Point here your object:
Its coordinates:

Observation.

An operator input the coordinates of your object into a computer controlling the 1-m telescope. After the telescope is pointed on it, check if it is seen into the guide.
The winner of the observational round competition is one who sees the faintest star at a minimum distance from the Sun.

Observational round by photos

Groups A and B.

Sorry, photos are possible only in SAO.

Photo 1.

What nebulae do you recognize?
Why most of them are red, but some are blue?

Photo 2.

What stellar clusters are seen in the photo?
What constellations do the photo borders cross?

What part of the Galaxy is seen in Photo 1 and 2?

Photo 3.

What objects are seen in the photo, their names or at least the types?
In what region of the Galaxy they are?

Photo 4.

Australian aborigines call this system of dark nebulae "Emu" (Australian ostrich).
In what constellations are its body, neck and head?
What object of the photo is the nearest and the most distant?