



XXII Международная астрономическая олимпиада

XXII International Astronomy Olympiad

Китай, Вэйхай

27.X. – 04.XI. 2017

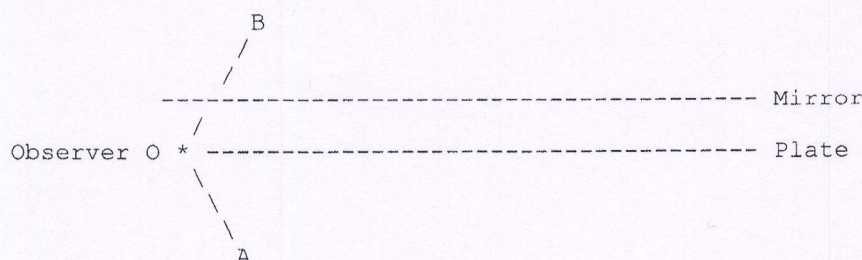
Weihai, China

Язык	<u>English</u>
language	

Theoretical round. Problems to solve

- α -1. Double star.** A double star consists of components by all physical characteristics equal to α Centauri **A** and α Centauri **B**, which are rotating around the common center of gravity by circular orbits. As observed from the Earth the angular distance between the components varies from 0.17" till 2.2" with a period of $\tau = 39.6$ years. Find the distance to the double star.
- β -1. Double star.** A double star consists of components by all physical characteristics equal to α Centauri **A** and α Centauri **B**, which are rotating around the common center of gravity by circular orbits. As observed from the Earth the angular distance between the components varies from 0.17" till 2.2" with a period of $\tau = 39.6$ years. Find the apparent magnitude of every component and also their combined magnitude.
- α -2. Extraterrestrial summit.** Extraterrestrial Bear and Extraterrestrial Penguin living in different planetary systems of our Galaxy, came to a summit organized at the Intercivilizational Space Station (ISS) somewhere in the depths of space, where no one star is visible brighter than 1^m. However, it appeared that both stars, from which planetary systems the Bear and the Penguin came, are visible with the naked eye at the summit (assume the sensitivity of the retina of these extraterrestrial animals to be the same as of humans), and the angular distance between them is equal to $\beta = 30^\circ$.
- 2.1.** Find the possible minimum and maximum linear distance between the native stars of the Bear and the Penguin. Consider the planetary systems are possible near the stars of spectral classes from **A** to **M** of main sequence.
- 2.2.** Include an artistic picture with an image of the Extraterrestrial Bear and Extraterrestrial Penguin (and possibly other extraterrestrial animals) on the ISS.
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- 2.1.** Find the possible minimum and maximum linear distance between the native stars of the Bear and the Penguin? Give the answers in numerical form, and if it is not possible, as a function of the angle β . Consider the planetary systems are possible near the stars of spectral classes from **A** to **M** of main sequence.
- 2.2.** Include an artistic picture with an image of the Extraterrestrial Bear and Extraterrestrial Penguin (and possibly other extraterrestrial animals) on the ISS.

- $\alpha\beta$ -3. Mirror and plate.** There is a system, consisting of a plane mirror (100% reflection) and a plane glass plate that transmits $K\%$ of the light and reflects the other $(100-K)\%$ (this characteristics is the same for the light coming from both the directions). The mirror and plate are parallel and infinite on their right side. An observer is placed at the point O (marked by *) and sees a star with a magnitude 2^m within a cone around direction «A». What magnitude(s) star(s) (if any) would the observer see in a cone near direction «B» that is symmetrical to «A»? Calculate numerical value for $K = 50\%$ and $K = 5\%$ for each such a star (if any visible) or explain why no stars are visible.

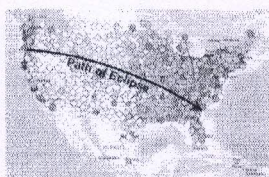


- α -4. Eclipse in USA.** A little more than two months ago, on August 21, 2017 from West to East of the USA territory a total solar eclipse was observed. The middle line of the track of the eclipse is shown schematically on the map. Below are four pictures taken by the Bulgarian-Russian group of observers who were in state of Oregon, through which the Moon's shadow ran as it shown in Fig. α 4. (see separate sheet). The local time (UT -07) of the shots is indicated below each image. By using the data and making calculations, estimate:

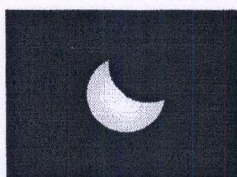
- 4.1. altitude of the Sun in Oregon at the moment of totality;
- 4.2. time t (in seconds) between the positions 1 and 2 of the shadow as marked at Fig. α 4.

- β -4. Eclipse in USA.** A little more than two months ago, on August 21, 2017 from West to East of the USA territory a total solar eclipse was observed. The middle line of the track of the eclipse is shown schematically on the map. Below are four pictures taken by the Bulgarian-Russian group of observers who were near the West coast, in the state Oregon, through which the Moon's shadow ran almost along the latitude $\varphi = 45^\circ$. The local time (UT -07) of the shots is indicated below each image. At the moment of totality the Sun was in the South-Eastern part of the sky, in $\chi = 59,5^\circ$ from the South in azimuth, at an altitude of $h = 41.9^\circ$ above the horizon. By using the data and making calculations, estimate:

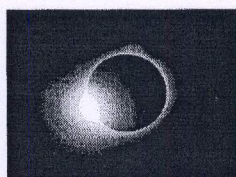
- 4.1. the speed of the Moon's shadow in the state Oregon;
- 4.2. the width of the path of the total eclipse (in km) on its territory.



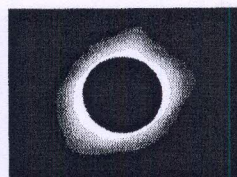
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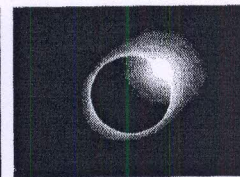
09:44:42



10:20:03



10:20:17



10:22:14

α -5. Whirlpool galaxy. An imaging observation of Messier object M51, consisted of galaxy NGC 5194 ($\alpha = 13^{\text{h}}29^{\text{m}}56^{\text{s}}$, $\delta = +47^{\circ}13'50''$) and its companion NGC 5195, was made by the 1-m telescope of Weihai Observatory (WHO), on December 25, 2014. The V-band image is shown in Fig. α 5. (see separate sheet), the bounding box marks the field of view of the image taken by the telescope (with focal length of 8 meters) and the PI CCD (2048×2048 , pixel size $13.5 \mu\text{m} \times 13.5 \mu\text{m}$).

5.1. Find the Beijing time (UTC+08, write the answer in 24h format: hh:mm) of the upper culmination of NGC 5194 in Weihai Observatory on the observing date, in form of « $T_c = \dots$ ».

5.2. Estimate the angular size (diameter) of NGC 5194 (in units of arc minutes, write the answer in form of « $\beta = \dots$ »).

5.3. If the physical size of NGC 5194 is known as about half the size of the Milky Way Galaxy, estimate the distance to M51 (in units of Mpc, write the answer in form of « $L = \dots$ »).

5.4. Which is the morphological type of NGC 5194 ("elliptical", "spiral", "barred spiral", "irregular")? Write the answer in English in form of «Type = ...».

β -5. Seyfert galaxy. The low-resolution spectrum of a galaxy: NGC 7479 ($\alpha = 23^{\text{h}}04^{\text{m}}57^{\text{s}}$, $\delta = +12^{\circ}19'22''$) was observed by the 2.16 m telescope of Xinglong Station near Beijing, National Astronomical Observatories of China, on September 14, 2009. The red part of this spectrum is shown in Fig. β 5 (see separate sheet). The emission lines in the part of the spectrum are (from left to right): [NII]a, H α , [NII]b.

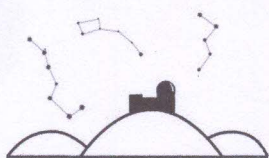
5.1. Find the Beijing time (UTC+8, write the answer in 24h format: hh:mm) of the upper culmination of this galaxy in Xinglong Observatory on the observing date, in form of « $T_c = \dots$ ».

5.2. Estimate the redshift z of this galaxy (write the answer in form of « $z = \dots$ »).

5.3. Find the distance to NGC 7479 (in units of Mpc, write the answer in form of « $D = \dots$ »).

5.4. Estimate the full width at half maximum (FWHM) of the H α line (in units of km/s, write the answer in form of «FWHM(H α) = ...»).

5.5. If the galaxy is known as a Seyfert galaxy, based on the line width of H α , which type it should be ("Seyfert-I" or "Seyfert-II")? Write the answer in English in form of «Type = ...». (Assume that the instrumental broadening can be neglected.)



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ЯЗЫК

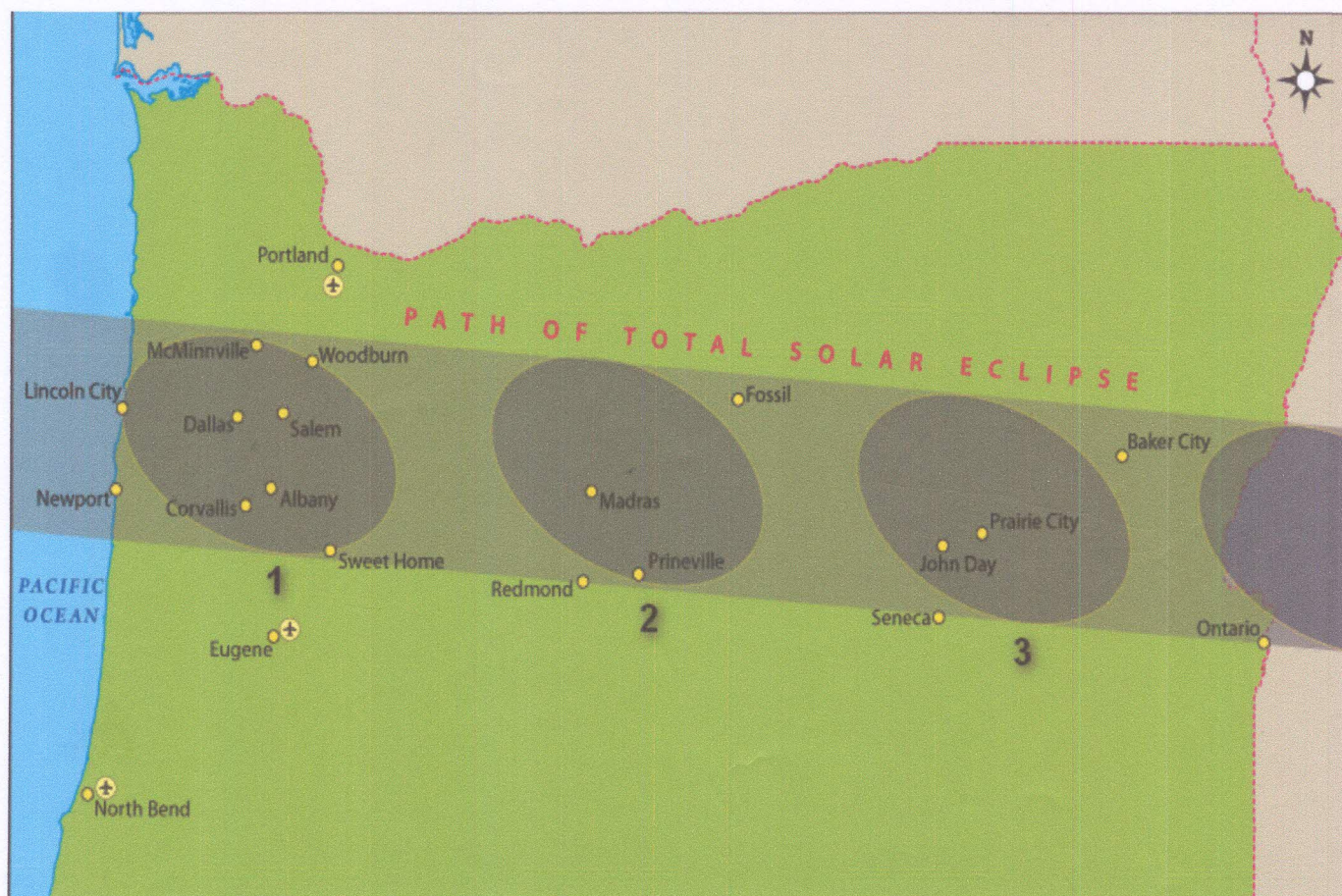
Русский

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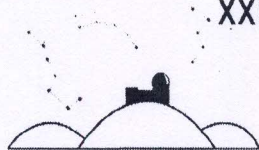
English

Рис. к задаче 4.

Fig. for problem 4.



$\alpha 4$



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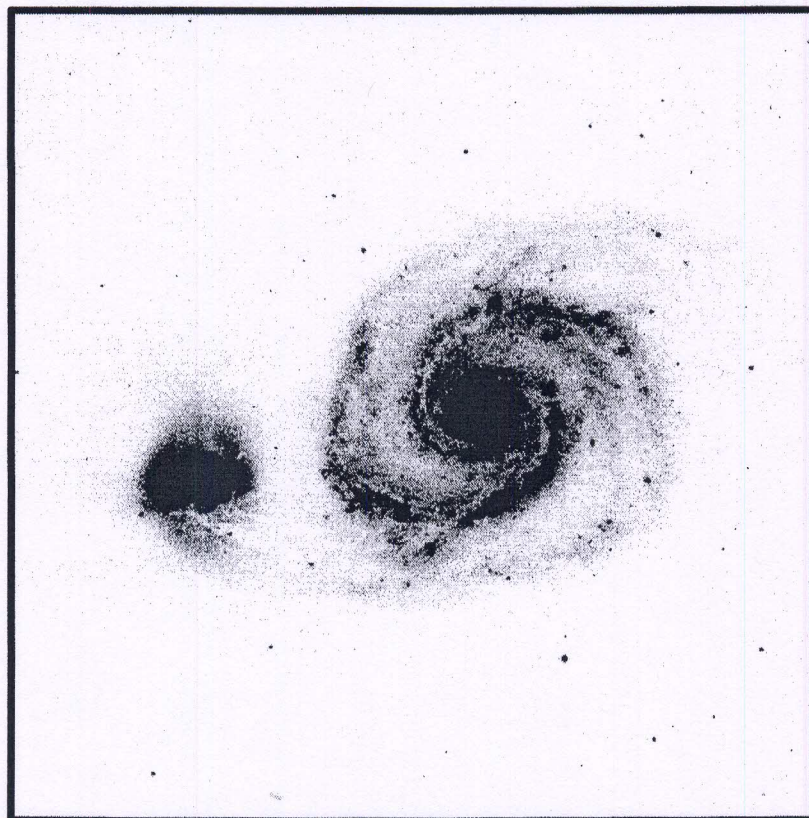
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язык language	<u>Русский</u>
язык language	<u>English</u>

Рис. к задаче 5.

Fig. for problem 5.



Данные о некоторых звёздах

Data of some stars

			R.A.	DEC	ρ	Зв. вел. Mag.	Температура Temperature	Масса Mass
Солнце	Sun	☉	0 ^h – 24 ^h	-23°26' – +23°26'	8 ^h .794	-26 ^m .74	5777 K	1 M _☉
Бетельгейзе	Betelgeuse	α Ori	05 ^h 55 ^m 10 ^s	07° 24' 25"	0 ^h .005	0 ^m .5	3590 K	11.6 M _☉
Вера	Vega	α Lyr	18 ^h 36 ^m 56 ^s	38° 47' 01"	0 ^h .130	0 ^m .03	9600 K	2.14 M _☉
Наос	Naos	ζ Pup	08 ^h 03 ^m 35 ^s	-40° 00' 12"	0 ^h .003	2 ^m .21	42000 K	40 M _☉
Толиман	Toliman (Rigel Kent)	α Cen A B	14 ^h 39 ^m 36 ^s	-60° 50' 07"	0 ^h .747	-0 ^m .01 1 ^m .33	5810 K 5260 K	1.11 M _☉ 0.93 M _☉
Проксима Центавра	Proxima Centauri	V645 Cen, α Cen C	14 ^h 29 ^m 43 ^s	-62° 40' 46"	0 ^h .769	11 ^m .06	3040 K	0.123 M _☉

Координаты	Coordinates	WHO Observatory	Xinglong Observatory
φ (N / с.ш.)		37° 32'	40° 24'
λ (E / в.д.)		122° 03'	117° 35'
Часовой пояс	Timezone	UT+08	UT+08



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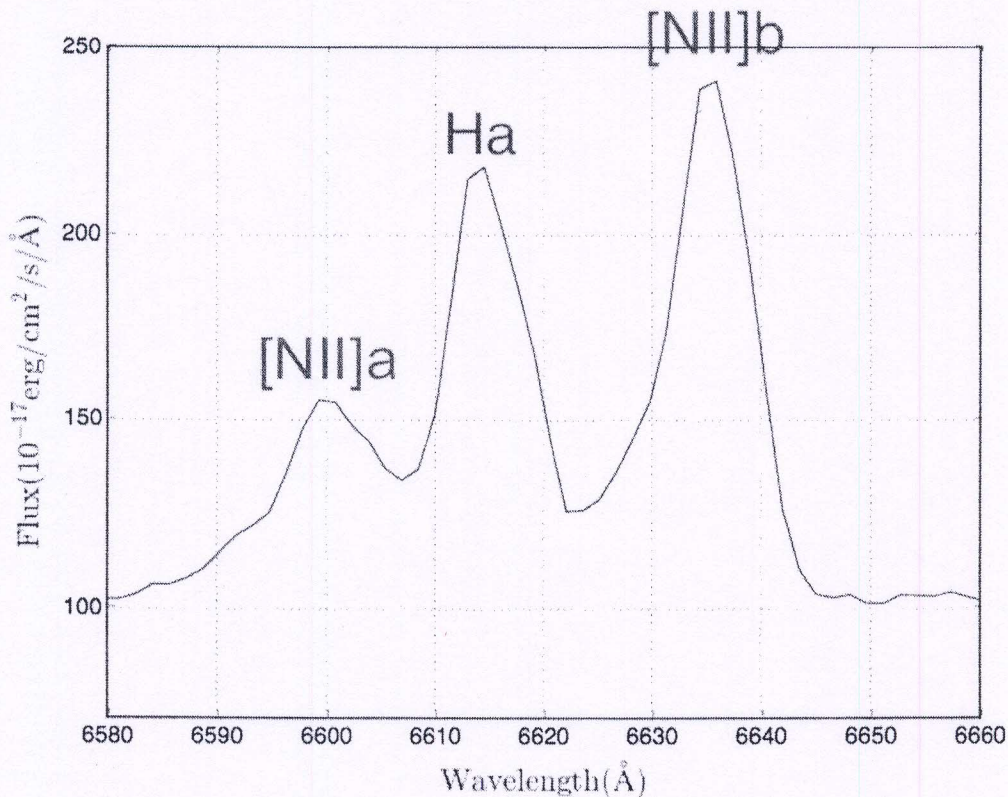
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ЯЗЫК	<u>Русский</u>
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Рис. к задаче 5.

Fig. for problem 5.



Данные о некоторых звёздах

Data of some stars

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Солнце	Sun	☉	0 ^h – 24 ^h	-23°26' – +23°26'	8 ^m .794	-26 ^m .74	5777 K	1 M _☉
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φ (N / с.ш.)		37° 32'	40° 24'
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