Theoretical round. Problems to solve

1. **Noon at the Olympiad.** Yesterday, on October 16, 2015, the upper culmination of the Sun at the venue of the Olympiad was at 11:29:43 local time. Calculate as accurate as possible at what time the upper culmination of the Sun will be (or was) today.

   Estimate the difference Δh in the height of the Sun at the culminations yesterday and today.

2. **Eclipse on the Poles.** The White Bear and the Penguin from the previous International Astronomy Olympiads returned to their poles (North and South respectively), and decided to observe an annular solar eclipse. The Penguin was lucky to see an amazing picture: at the maximum phase of the eclipse the centres of both discs, solar and lunar, appeared just on the visible horizon. And what did the Bear observe at this time? Draw what the White Bear saw at that moment, and also contour by dotted line the true positions of the Sun and the Moon. Assume that the Earth is spherical. The drawing should include an artistic picture with an image of the Bear on North Pole; necessary sizes or angular sizes should be pointed out in the picture. Recollect for yourself the necessary information about the animals.

3. **Close conjunction.** Some time after the events described in the previous problem (nobody knows even the order of magnitude how long after – minutes, or hours, or days, or years ...), Venus at the point of eastern elongation came to close conjunction with Mars, which was located near the aphelion of its orbit. At the same time a total lunar eclipse occurred on the Earth.

   3.1. Draw the corresponding scheme.

   3.2. Explain, which animal (sitting at the same poles) may see this lunar eclipse. (At the very end of your explanation write as answer **B+** or **B–** for the Bear and **P+** or **P–** for the Penguin.) An artistic picture of the observations of the animals is welcome.

   3.3. Calculate in which constellation the eclipsed Moon was observed.

   3.4. Estimate minimal possible time passed from the situation of the previous problem to the situation of the current one.

4. **Alpha Centauri.** Calculate, which star emits more energy: the Sun or Alpha Centauri A+B.

5. **Motion of a satellite.** An artificial satellite, moving in equatorial, slightly elliptical orbit passed the perigee point at the height of H_P = 428.0 km from the sea level; and its speed at the point was 0.6% higher than the circumferential velocity of the given point. Find the time after which the satellite will reach the height H_1 = 498.0 km?

Theoretical round. Problems to solve

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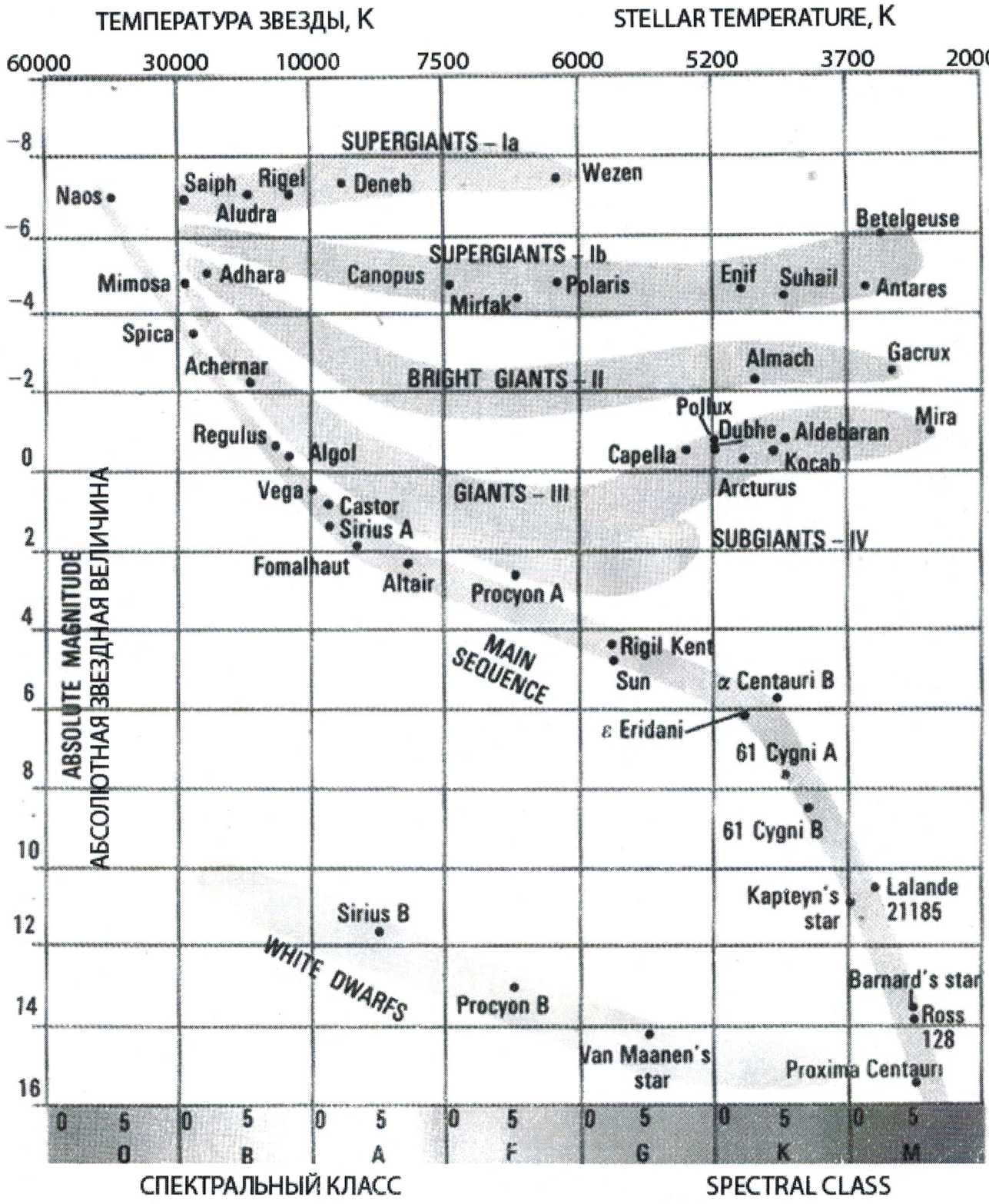
4. **Constellation of White Leopard.** According to an ancient legend of Middle Volga there was a constellation called White Leopard (Белый Барс – Pardus Album) in the sky in the very past, in which the number of stars were exactly equal to the number of letters in the Greek alphabet, and the stars had magnitudes α PaA – $+0.10^m$, β PaA – $+0.20^m$, γ PaA – $+0.30^m$, δ PaA – $+0.40^m$, and so on with adding 0.10^m till ω PaA. Calculate the total magnitude of the stars of this constellation.

5. **Spiral galaxy.** A spiral galaxy consisting mainly of A7-A8 spectral class stars was discovered in the Southern Cross (Crux) constellation. The galaxy may be seen as oval of about 40 by 30 arcsec in the sky. The broadened Hα line is observed at wavelengths approximately from 7054 Å to 7057 Å in the spectrum of the galaxy. Other lines in the spectrum are also shifted and broadened proportionally. Estimate the number of stars in the galaxy.

Диаграмма Герцшпрунга-Рассела

Hertzsprung-Russell diagram



АСТРОНОМИЧЕСКОЕ ОБЩЕСТВО

EURO-ASIAN ASTRONOMICAL SOCIETY

Round **Theo**

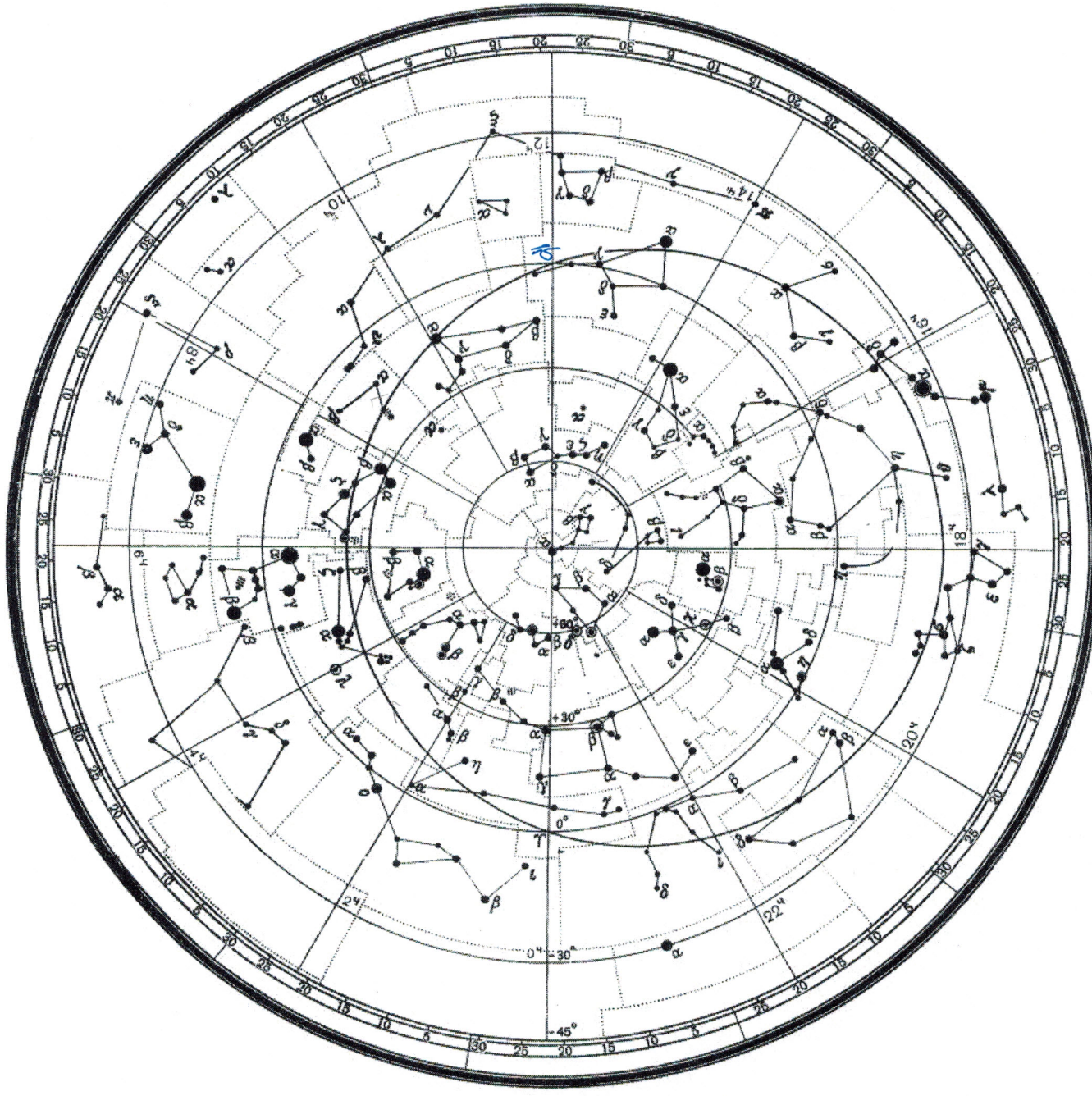
Group **α** **β**

язык / language	**Русский**
язык / language	**English**

XX Международная астрономическая олимпиада

XX International Astronomy Olympiad

Россия, Татарстан, Казань 15 – 23. X. 2015 Kazan, Tatarstan, Russia



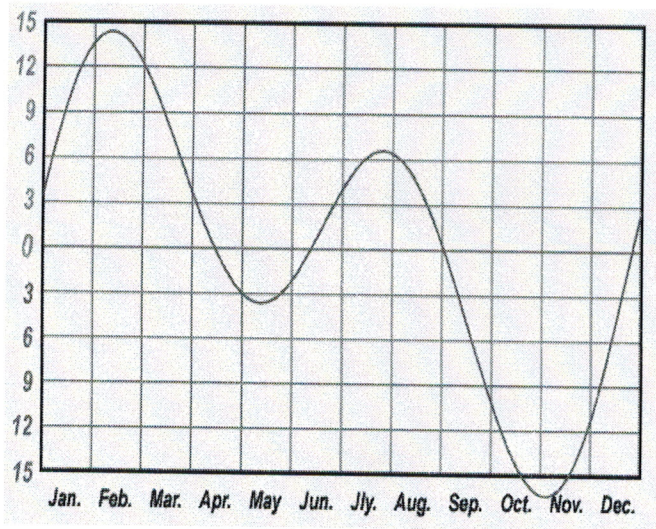
Элементы орбит и физические характеристики планет, Солнца и Луны

Parameters of orbits and physical characteristics of planets, Sun and Moon

Небесное тело, планета / Body, planet	Среднее расстояние от центрального тела / Average distance to central body		Сидерический период обращения / Sidereal (or analogous) period		Эксцентриситет, e / Eccentricity e	Экваториальн. диаметр, км / Equat. diameter, km	Масса, 10^{24} кг / Mass, 10^{24} kg	Средняя плотность, г/см^3 / Av. density, g/cm^3	Ускор. своб. пад. у пов., м/с^2 / Grav. acceler. at surf., m/s^2	Макс. блеск, вид. с Земли **) / Max. magn. from Earth **)	Альбедо / Albedo
	в астр. ед. / in astr. units	в млн. км / in mln. km	в тропич. годах / in tropical years	в средних сутках / in days							
Солнце Sun	$1{,}6\cdot10^{9}$	$2{,}5\cdot10^{11}$	$2{,}2\cdot10^{8}$	$8\cdot10^{10}$		1392000	1989000	1,409		$-26{,}8^{m}$	
Меркурий Mercury	0,387	57,9	0,241	87,969	0 ,206	4 879	0,3302	5,43	3,70	$-2{,}2^{m}$	0,06
Венера Venus	0,723	108,2	0,615	224,701	0,007	12 104	4,8690	5,24	8,87	$-4{,}7^{m}$	0,78
Земля Earth	1,000	149,6	1,000	365,256	0,017	12 756	5,9742	5,515	9,81		0,36
Луна Moon	0,00257	0,38440	0,0748	27,3217	0,055	3 475	0,0735	3,34	1,62	$-12{,}7^{m}$	0,07
Марс Mars	1,524	227,9	1,880	686,980	0,093	6 794	0,6419	3,94	3,71	$-2{,}0^{m}$	0,15
Юпитер Jupiter	5,204	778,6	11,862	4 332,59	0,048	142 984	1899,8	1,33	24,86	$-2{,}7^{m}$	0,66
Сатурн Saturn	9,584	1433,7	29,458	10 759,20	0,054	120 536	568,50	0,70	10,41	$0{,}7^{m}$	0,68
Уран Uranus	19,191	2871,0	84,015	30 685,93	0,046	51 118	86,625	1,30	8,44	$5{,}5^{m}$	0,74
Нептун Neptune	30,071	4498,6	164,778	60 187,64	0,008	49 532	102,78	1,76	11,20	$7{,}8^{m}$	0,58

**) Для внешних планет и Луны – в среднем противостоянии.

**) For outer planets and Moon – in mean opposition.



Координаты / Coordinates	Обсерватория / Observatory	Казанский Кремль / Kazan kremlin	Петровское / Petrovskoye
λ (E / в.д.)	48° 49′	49° 06′	49° 06′
φ (N / с.ш.)	55° 50′	55° 48′	55° 41′
Часовой пояс / Timezone	UT+3	UT+3	UT+3

Уравнение времени **Equation of time**

Некоторые константы и формулы

Some constants and formulae

Скорость света в вакууме, c (м/с)	299 792 458	Speed of light in vacuum, c (m/s)
Гравитационная постоянная, G ($Н \cdot м^2/кг^2$)	$6.674 \cdot 10^{-11}$	Constant of gravitation, G ($N \cdot m^2/kg^2$)
Солнечная постоянная, A ($Вт/м^2$)	1367	Solar constant, A (W/m^2)
Параметр Хаббла, среднее значение H_0 (км/с/МПк) диапазон значений	68 50-100	mean value Hubble parameter, diapason of values H_0 (km/s/Mpc)
Постоянная Планка, h (Дж·с)	$6.626 \cdot 10^{-34}$	Plank constant, h (J·s)
Заряд электрона, e (Кл)	$1.602 \cdot 10^{-19}$	Charge of electron, e (C)
Масса электрона, m_e (кг)	$9.109 \cdot 10^{-31}$	Mass of electron, m_e (kg)
Соотношение масс протона и электрона	1836.15	Proton-to-electron ratio
Постоянная Фарадея, F (Кл/моль)	96 485	Faraday constant, F (C/mol)
Магнитная постоянная, μ_0 (Гн/м)	$1.257 \cdot 10^{-6}$	Magnetic constant, μ_0 (H/m)
Универсальная газовая постоянная, R (Дж/моль/K)	8.314	Universal gas constant, R (J/mol/K)
Постоянная Больцмана, k (Дж/K)	$1.381 \cdot 10^{-23}$	Boltzmann constant, k (J/K)
Постоянная Стефана-Больцмана, σ ($Вт/м^2/K^4$)	$5.670 \cdot 10^{-8}$	Stefan-Boltzmann constant, σ ($W/m^2/K^4$)
Константа смещения Вина, b (м·K)	0.002897	Wien's displacement constant, b (m·K)
Лабораторная длина волны Hα (Å)	6562.81	Laboratory wavelength of Hα (Å)
Длина тропического года, T (сут)	365.242199	Tropical year length, T (days)
Период обращения узлов лунной орбиты (лет)	-18.6	Nodal period of lunar orbit (years)
Стандартная атмосфера (Па)	101 325	Standard atmosphere (Pa)
Ослабление видимого света слоем 1 атмосферы (минимально)	19%, 0.23^m	Visible light extinction by the terrestrial atmosphere in zenith (minimum)
Высота однородной атмосферы (м)	7991	Height of homogeneous atmosphere (m)
Показатель преломления воды при 20°C, n	1.334	Refractive index of water for 20°C, n
Момент инерции шара	$I = {}^2/_5\, MR^2$	Moment of inertia of a solid ball
Объём шара	$V = {}^4/_3\, \pi R^3$	Volume of a ball
Площадь сферы	$S = 4\pi R^2$	Area of sphere
π	3.14159265	π
e	2.71828183	e
Золотое сечение, φ	1.61803399	Golden ratio, φ

20 самых ярких звёзд неба

20 brightest stars in the sky

			RA	DEC	*p*	m	S C
Альтаир	Altair	α Aql	$19^h\ 50^m\ 47^s$	08° 52' 06"	0".195	$0^m.77$	A7
Капелла	Capella	α Aur	$05^h\ 16^m\ 41^s$	45° 59' 53"	0".073	$0^m.08$	G5+G0
Арктур	Arcturus	α Boo	$14^h\ 15^m\ 38^s$	19° 10' 57"	0".089	$-0^m.04^V$	K1
Канопус	Canopus	α Car	$06^h\ 23^m\ 57^s$	-52° 41' 45"	0".028	$-0^m.72$	F0
Толиман	Toliman (Rigel Kent)	α Cen A α Cen B	$14^h\ 39^m\ 36^s$	-60° 50' 07"	0".747	$-0^m.01$ $1^m.33$	G2 K1
Хадар	Hadar	β Cen	$14^h\ 03^m\ 49^s$	-60° 22' 23"	0".009	$0^m.61$	B1
Сириус	Sirius	α CMa	$06^h\ 45^m\ 09^s$	-16° 42' 58"	0".375	$-1^m.46$	A1
Процион	Procyon	α CMi	$07^h\ 39^m\ 18^s$	05° 13' 30"	0".288	$0^m.38$	F5
Акрукс	Acrux	α Cru	$12^h\ 26^m\ 36^s$	-63° 05' 57"	0".010	$0^m.77$	B0
Бекрукс	Becrux	β Cru	$12^h\ 47^m\ 43^s$	-59° 41' 20"	0".009	$1^m.30$	B0
Денеб	Deneb	α Cyg	$20^h\ 41^m\ 26^s$	45° 16' 49"	0".002	$1^m.25$	A2
Ахернар	Achernar	α Eri	$01^h\ 37^m\ 43^s$	-57° 14' 12"	0".026	$0^m.46$	B3
Поллукс	Pollux	β Gem	$07^h\ 45^m\ 19^s$	28° 01' 35"	0".097	$1^m.14$	K0
Вега	Vega	α Lyr	$18^h\ 36^m\ 56^s$	38° 47' 01"	0".123	$0^m.03$	A0
Бетельгейзе	Betelgeuse	α Ori	$05^h\ 55^m\ 10^s$	07° 24' 25"	0".005	$0^m.5^V$	M2
Ригель	Rigel	β Ori	$05^h\ 14^m\ 32^s$	-08° 12' 06"	0".013	$0^m.12$	B8
Фомальгаут	Fomalhaut	α PsA	$22^h\ 57^m\ 39^s$	-29° 37' 20"	0".130	$1^m.16$	A3
Антарес	Antares	α Sco	$16^h\ 29^m\ 24^s$	-26° 25' 55"	0".024	$0^m.96$	M1+B4
Альдебаран	Aldebaran	α Tau	$04^h\ 35^m\ 55^s$	16° 30' 33"	0".048	$0^m.85^V$	K5
Спика	Spica	α Vir	$13^h\ 25^m\ 12^s$	-11° 09' 41"	0".023	$0^m.98$	B1

Некоторые другие звёзды

Some other stars

Хамаль	Hamal	α Ari	$02^h\ 07^m\ 10^s$	23° 27' 45"	0".050	$2^m.01$	K2
Полярная	Polaris	α UMi	$02^h\ 31^m\ 49^s$	89° 15' 51"	0".007	$1^m.97^V$	F7
Кохаб	Kochab	β UMi	$14^h\ 50^m\ 42^s$	74° 09' 20"	0".025	$2^m.07$	K4
Проксима Центавра	Proxima Centauri	**V645** Cen, α Cen **C**	$14^h\ 29^m\ 43^s$	-62° 40' 46"	0".769	$11^m.05$	M5.5

Греческий алфавит

Greek alphabet

Α	α	альфа	alpha	Ι	ι	йота	iota	Ρ	ρ	ро	rho
Β	β	бета	beta	Κ	κ	каппа	kappa	Σ	σ	сигма	sigma
Γ	γ	гамма	gamma	Λ	λ	ламбада	lambda	Τ	τ	тау	tau
Δ	δ	дельта	delta	Μ	μ	мю	mu	Υ	υ	ипсилон	upsilon
Ε	ε	эпсилон	epsilon	Ν	ν	ню	nu	Φ	φ	фи	phi
Ζ	ζ	дзета	zeta	Ξ	ξ	кси	xi	Χ	χ	хи	chi
Η	η	эта	eta	Ο	ο	омикрон	omicron	Ψ	ψ	пси	psi
Θ	θ	тета	theta	Π	π	пи	pi	Ω	ω	омега	omega

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Group . .

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язык / language	fill this cell in Russian
язык / language	fill this cell in English
язык / language	fill this cell in Native

Пожалуйста, пишите текст только внутри очерченных гарниц!

Please, write text inside the marked borders only!

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