سوالات و پاسخ

مرحله دوم

نخستین المپیاد

نجوم و اخترفیزیک

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[illegible]

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$6/67\times10^{-11}\,m^3kg^{-1}s^{-2}$	Š ¿ YÊ€¿³ ZdÆZmi G
$3\times10^{8}\,ms^{-1}$	• Âd¿Ÿ € ‡ c
$3/09\times10^{16}\,m$	® ‡ • Z a pc
$1/50\times10^{11}\,m$	Ê » Â|m ¿Y Á Au
$9/46\times10^{15}\,m$	É • Âµ¿Z ‡ Ly
$6/96\times10^{8}\,m$	| Ì ‹ • Â•yZ ‹ $R_{\odot}$
$6/38\times10^{6}\,m$	¾ Ì »Z ‹ $R_{\oplus}$
$1/74\times10^{6}\,m$	Ã Z Z» ‹
$3/84\times10^{8}\,m$	Ã ZÉ» Y•|Z» ‹
$5/97\times10^{22}\,kg$	¾ Ì »€ m $M_{\oplus}$
$5777\,K$	| Ì ‹ • ÂÉyZ » { $T_{\odot}$
$3/85\times10^{26}\,W$	| Ì ‹ • ÂÊy³ | À Œ y• { $L_{\odot}$
$1/37\times10^{3}\,Wm^{-2}$	É | Ì ‹ • Âd yZ i
$-26/8$	| Ì ‹ • ÂÉy€ Å•Z « $m_{\odot}$
$70\,km\,s^{-1}Mpc^{-1}$	¶] ZdÅZ i H

(1 [illegible] M_A, M_B [illegible]

[illegible] $M_A = 8M_B$, $d = 8R_B$: [illegible] R_A, R_B [illegible]

[illegible] m [illegible]

[illegible] m [illegible]

(2 [illegible] 60 [illegible]

[illegible]

[illegible] $R_1 = R_2 = R_\odot$ [illegible] $M_1 = M_2 = M_\odot$ [illegible]

[illegible]

(3 [illegible] 108 [illegible]

[illegible] $60^\circ N$ [illegible]

(4 [illegible] 1384 [illegible] 1176 [illegible] 27° [illegible] $48^\circ 30'$ [illegible]

[illegible] T [illegible] $(\Delta_\odot)$ [illegible] $34^\circ 48'$ [illegible]

[illegible]

5

$$L = M_{\odot} R v_{\odot} \qquad , \qquad \frac{1}{2}M(v_r^2 + v_\theta^2) + V(R) = E$$

v_r , v_θ

6

7

$5M_{\odot}$

$10^{-8} M_{\odot}/_{year}$

$10\,AU$

$\left(\frac{da}{dt}\right)$

$3/83 \times 10^{39}\, erg/s$

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Y ⁹ / ˆ m¾ ẸBY€ Ẽ Â Š« ¿ YÉ€Á³ €|‡¿€€]¨ •• ¥ f ŒZ €Ë]¨ •d Ÿ €Ä‡Ê ŒŸ €É³ Z Å µÁ €Z Ì ¿Ä ˜ •¬{ m º ˆ mÄ { Â|]Å Y Â y

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$F_A = F_B$: Ê Œ ¿µY{ Z̆Ä³ ẽ•¬{¿

$$\frac{Gm_A m}{(d-x)^2} = \frac{Gm_B m}{x^2} \Rightarrow \frac{x}{d-x} = \sqrt{\frac{m_B}{m_A}}$$

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$$\Rightarrow \frac{x}{d-x} = \sqrt{\frac{1}{8}} = \frac{1}{2\sqrt{2}} \Rightarrow x = \frac{d}{2\sqrt{2}+1}$$

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$$E_A = E_C$$

$$\Rightarrow U_A + K_A + U_B = U_c + K_c$$

$$\left.\begin{array}{l} \dfrac{-Gm_A m}{R_A} + \dfrac{1}{2}mv_\circ^2 - \dfrac{Gm_B m}{d-R_A} = \dfrac{-Gm_A m}{d-x} + \dfrac{1}{2}mv_c^2 - \dfrac{Gm_B m}{x} \\ v_c \approx \circ, m_A = 8m_B, d = 8R_B \end{array}\right\} \Rightarrow$$

$$v_\circ \approx \sqrt{2GM_B\left[\frac{8}{R_A} + \frac{1}{8R_B - R_A} - \frac{8}{5/91R_B} - \frac{1}{2/09R_B}\right]}$$

$$\Rightarrow v_\circ \approx \sqrt{2GM_B\left(\frac{8}{R_A} + \frac{1}{8R_B - R_A} - \frac{0/875}{R_B}\right)}$$

2)

$$BC = 0/1Au + 2R_{Sun} \Rightarrow GB = 0/05Au + R_{Sun} = 0/05 + 0/00464 = 0/05464$$

$$\sin i = \frac{AB}{GB} = \frac{0/00464}{0/05464} \Rightarrow i = 4/87$$

$i = 4/87$

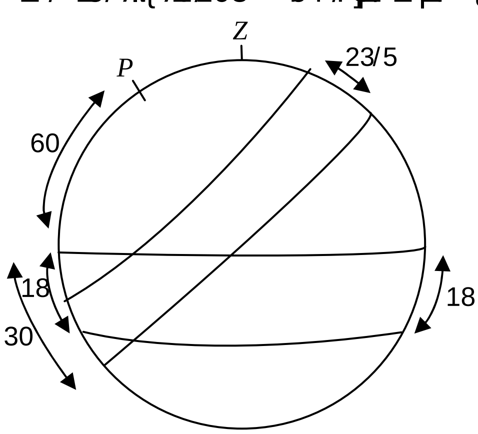
$$\frac{\quad}{\text{ستارگان دوتایی}} = \frac{4/87^\circ - 0^\circ}{90^\circ - 0^\circ} = \frac{4/87}{90} = 5/41\%$$

3)

18°

60

$30 - 18 = 12$



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$$\frac{\sin\delta_\odot}{\sin\varepsilon} = \frac{\sin\lambda_\odot}{\sin\frac{\pi}{2}}$$

$$\Rightarrow \sin\delta_\odot = \sin\lambda_\odot \sin\varepsilon$$

$$\Rightarrow \lambda_\odot = 31/4^\circ$$

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$$365\,day \qquad 360\,\deg$$

$$x\,day \qquad 31/4\,\deg$$

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$$365\,day \qquad 360\,\deg$$

$$47\,day \qquad \lambda\,\deg$$

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$$\frac{\sin\delta_\odot}{\sin\varepsilon} = \frac{\sin\lambda_\odot}{\sin\frac{\pi}{2}} \Rightarrow \sin\delta_\odot = \sin\lambda_\odot \sin\varepsilon \quad \Rightarrow \quad \delta_\odot = 16/6^\circ$$

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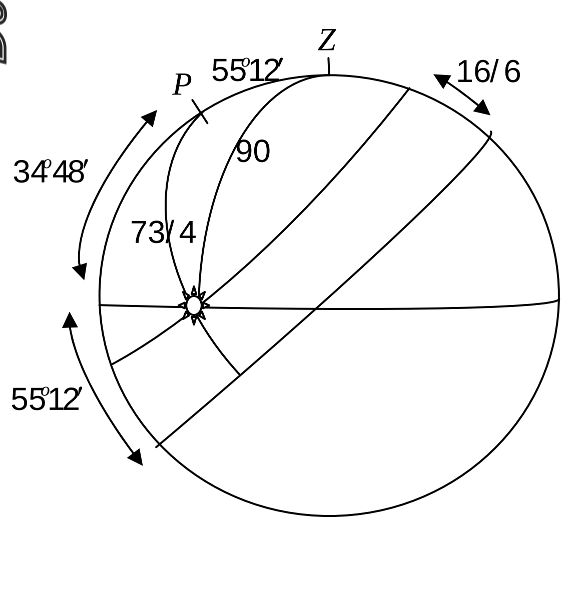

$$\cos 73/4 = \cos 90 \cos 55 + \sin 90 \sin 55 \cos A \Rightarrow$$

$$A = 69/6$$

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$$\cos 90 = \cos 73/54 \cos 55 + \sin 73/54 \sin 55 \cos H \Rightarrow$$

$$H = 101^\circ \Rightarrow \Delta T = 2H = 202^\circ \Rightarrow \Delta T = 13^h\ 30^m\ 40^s$$

$$E_{\odot} = K + U$$

$$\left.\begin{aligned} K &= \frac{1}{2} m_{\odot} V_s^2 \\ U &= \frac{-GMm_{\odot}}{R_{\circ}} \\ M &= \rho_{\circ} V = \rho_{\circ} \times \frac{4}{3}\pi R_{\circ}^3 \end{aligned}\right\} \Rightarrow E = \frac{1}{2} m_{\odot} V_s^2 - \frac{4}{3}\pi \rho_{\circ} G R_{\circ}^2 m_{\odot}$$

$$E = -\frac{GM_G m_{\odot}}{2a} = E_{\odot} = m_{\odot}\left(\frac{1}{2}V_s^2 - \frac{4}{3}\rho_{\circ} G R_{\circ}^2\right) \Rightarrow \frac{M_G}{a} = \frac{8}{3}\pi \rho_{\circ} R_{\circ}^2 - \frac{V_s^2}{G}$$

$$L = m_{\odot} R V$$

$$2a = 2R_{\circ} \Rightarrow a = R_{\circ}$$

$$L = m_{\odot} R_{\circ} (1+e) V_s = m_{\odot} R_{\circ} V_s \Rightarrow e = 0$$

$$\frac{a^3}{T^2} = \frac{GM_{\circ}}{4\pi^2} \Rightarrow T = \sqrt{\frac{a}{GM}}\, 2\pi a = \sqrt{\frac{1}{\frac{8}{3}\pi G \rho_{\circ} R_{\circ}^2 - V_s^2}}\, 2\pi R_{\circ}$$

$$2a = 2R_{\circ} \Rightarrow a = R_{\circ} \Rightarrow e = 0 \Rightarrow T = 2\pi R_{\circ} \sqrt{\frac{1}{\frac{8}{3}\pi G \rho_{\circ} R_{\circ}^2 - V_s^2}}$$

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$$\left.\begin{aligned} b &= R_\circ \\ \left(\frac{b}{a}\right)^2 &= 1-e^2 \end{aligned}\right\} \Rightarrow a\sqrt{1-e^2} = R_\circ$$

$$a_p = a(1-e) = p$$

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$$\left.\begin{aligned} E &= \frac{-GM_G\, m_\odot}{2a} = m_\odot\left(\frac{1}{2}V_s^2 - \frac{4}{3}\pi\rho_o G R_\circ^2\right) = K_p + U_p \\ K_p &= \frac{1}{2} m_\odot V_p^2 \\ V_p &= \frac{L}{m_\odot a_p} = \frac{L}{m_\odot p} = \frac{R_\circ V_s}{p} \\ &\left.\begin{aligned} U_p &= \frac{-GM' m_\odot}{p} \\ M' &= \rho_\circ \times \frac{4}{3}\pi p^3 \end{aligned}\right\} \Rightarrow U = -G\rho_\circ \frac{4}{3}\pi p^2 m_\odot \end{aligned}\right\} \Rightarrow$$

$$E = \frac{1}{2} m_\odot \frac{R_\circ^2 V_s^2}{p^2} - \frac{4}{3}\pi\rho_\circ m_\odot p^2 \Rightarrow \frac{4}{3}\pi\rho_\circ p^4 + \frac{E}{m_\odot} p^2 - \frac{R_\circ^2 V_s^2}{2} = \circ$$

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$$\Rightarrow p = \sqrt{\frac{-\frac{E}{m_\odot} + \sqrt{\left(\frac{E}{m_\odot}\right)^2 + \frac{8\pi\rho_\circ R_\circ^2 V_s^2}{3}}}{\frac{8}{3}\pi\rho_\circ}} = a(1-e)$$

$$\Rightarrow \sqrt{\frac{1+e}{1-e}} = \frac{a\sqrt{1-e^2}}{a(1-e)} = \frac{R_\circ}{p} \quad \Rightarrow \frac{1-e}{1+e} = \frac{\frac{8}{3}\pi\rho_\circ R_\circ}{\sqrt{\left(\frac{E}{m_\odot}\right)^2 + \frac{8\pi\rho_\circ R_\circ^2 V_s^2}{3}} - \frac{E}{m_\odot}}$$

$$e=\frac{\sqrt{\frac{8}{3}\pi\rho_o R_\circ^2 V_s^2+\left(\frac{E}{m_\odot}\right)^2}-\frac{8}{3}\pi\rho_o R_\circ-\frac{E}{m_\odot}}{\sqrt{\frac{8}{3}\pi\rho_o R_\circ^2 V_s^2+\left(\frac{E}{m_\odot}\right)^2}+\frac{8}{3}\pi\rho_o R_\circ-\frac{E}{m_\odot}}$$

$$a=\frac{R_\circ}{\sqrt{1-e^2}}\ ,\ T=2\pi a\sqrt{\frac{a}{GM}}=\frac{2\pi R_\circ}{\sqrt{1-e^2}}\sqrt{\frac{1}{\frac{8}{3}\pi G P_\circ R_\circ^2-V_s^2}}$$

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½ Y θ_A Á { $\alpha+\beta$ Ã • Y Ä | ¿ Ã • Z Ì | ‡ ¾ Ë { Ä º Ì Ä »] Â » Ã | Ë Ì] € e Z • u B' Ã • Z A' ‡ É Á • Z | Ë { Ä ¯

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89 day	θ_A
$T\ day$	2π

89 day	θ_B
$T\ day$	2π

$$\left.\begin{aligned}&\Rightarrow \theta_A=\frac{2\theta}{T_\oplus}89\\&\Rightarrow \theta_B=\frac{2\pi}{T_p}89\end{aligned}\right\}\Rightarrow \alpha=\theta_A-\theta_B=(2\pi)(89)\left(\frac{1}{T_\oplus}-\frac{1}{T_p}\right)$$

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$$2\pi=\theta_A-\theta_B=2\pi\ (489)\left(\frac{1}{T_\oplus}-\frac{1}{T_p}\right)$$

$$\Rightarrow \frac{1}{365/\ 25}-\frac{1}{T_p}=\frac{1}{489}$$

$$\Rightarrow T_p=1443/\ 3$$ • Á · Ã • Z Ì ‡ Â [Á ¿ Z Ã • e Á {

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$$\alpha_{rad} = 2\pi(89)\left(\frac{1}{365/25} - \frac{1}{1443/3}\right) \Rightarrow \alpha = 1/14\, rad$$

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$$\cos\alpha = \frac{d_1}{d_2} \Rightarrow d_2 = \frac{d_1}{\cos\alpha} \Rightarrow d_2 = 2/41\, d_1$$

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$$\left.\begin{array}{l} L = 3/83 \times 10^{9}\, erg/s \\ 1J = 10^{7}\, erg \end{array}\right\} \Rightarrow L = 3/83 \times 10^{32}\, J/s$$

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$$L = \frac{\Delta E}{\Delta t} = \frac{\Delta m\, c^2}{\Delta t} \Rightarrow \frac{\Delta m}{\Delta t} = \frac{3/83 \times 10^{32}\, j/s}{(3 \times 10^{8}\, m/s)^2} = 4/255 \times 10^{15}\, kg/s = 4/255 \times 10^{15} \frac{3/15 \times 10^{7}}{1/99 \times 10^{30}} \frac{M_\odot}{year}$$

$$\Rightarrow \frac{\Delta m_L}{\Delta t} = 6/747 \times 10^{8}\, M_\odot/year$$ Š] Ž€e • Y{ € mŠ Å Z ¯

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$$\frac{\Delta m}{\Delta t} = \frac{\Delta m_L + \Delta m_w}{\Delta t} = -7/747 \times 10^{8}\, M_\odot/year$$

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$$v = \sqrt{\frac{GM}{a}} \quad Á \quad \frac{L}{m} = \sqrt{GMa} \Rightarrow \left(\frac{L}{m}\right)^2 = GMa$$

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$$\frac{G(M\Delta a + a\Delta M)}{\Delta t} = ∘ \Rightarrow$$

$$\frac{\Delta M/\Delta t}{M} = -\frac{\Delta a/\Delta t}{a} \Rightarrow \Delta a/\Delta t = -\frac{\Delta M/\Delta t}{M} a = -\frac{-7/747 \times 10^{8}\, M_\odot/year}{5 M_\odot}\, 10\, Au$$

$$\Rightarrow a = \frac{\Delta a}{\Delta t} \approx 1/55 \times 10^{7}\, Au/year$$

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$$v = R_{Mercury}\frac{2\pi}{T} = \frac{5}{2}\times 10^{6} m \frac{2\pi}{59\times 24\times 3600} = 3/08 \, {}^{m}\!/\!{}_{s}$$

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$$\left.\begin{aligned} \frac{v}{c} &= \frac{\Delta\lambda}{\lambda_\circ} = \frac{\lambda-\lambda_\circ}{\lambda_\circ} \\ \lambda &= \frac{c}{\nu} \end{aligned}\right\} \Rightarrow \frac{v}{c} = \frac{\frac{c}{\nu}-\frac{c}{\nu_\circ}}{\frac{c}{\nu_\circ}} = \frac{\nu_\circ}{\nu} - 1$$

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$$\Rightarrow \frac{\nu_\circ}{\nu} = \frac{v}{c} + 1$$

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$$\frac{v}{c} = \frac{3/08 \, {}^{m}\!/\!{}_{s}}{3\times 10^{8} \, {}^{m}\!/\!{}_{s}} = 1/027\times 10^{-8}$$

$$\left.\begin{aligned} &\Rightarrow \frac{\nu_\circ}{\nu} - 1 = 1/027\times 10^{-8} \\ &\nu_\circ = 30\,GHz = 3\times 10^{10}\,Hz \end{aligned}\right\} \Rightarrow \Delta\nu = \nu - \nu_\circ = \pm\, 308/1\,Hz \approx \pm\, 310\,Hz$$

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