W 12 DUE NOW! Please fill out student questionnaires (teaching/course

EMINDER: EXAM ONLINE FRIDAY 5/1 10:00 a.m → 6:45 p.m. Submission deadline 7:00p

cture Notes, HW + Sol, Midterm + Sol, Books, your notes ⟹ EMAIL

ypes, distribution, properties, histories, final states etc. of stars ⇒ H.R. diagram: OBAF
↳ Supernovae, planetary nebulae, BH, Neutron stars, black holes, pulsars | White dwa
brown dw
Red Giants, SG

" " " , > " , structure of galaxies ⇒ E2, S3, Ir ; AGN

" " of Universe : Inflation → radiation dominated → baryon domination → Genesis → fir
(nuclei) CMB
expansion

lementary particles, properties, reactions
fundamental

First stars and galaxies

SR: time dilation $\sim \frac{1}{\sqrt{1-v^2/c^2}}$ ⇒ Redshift $\frac{\lambda_{obs}}{\lambda_{emit}} = \frac{1+v/c}{\sqrt{1-v^2/c^2}} = \sqrt{\frac{1+v/c}{1-v/c}} = \underset{\text{redshift}}{z+1}$

$E_{rest} = mc^2$ $E_{rel} = pc$ general $E = \sqrt{m^2c^4+p^2c^2}$

Grav.: $\frac{v^2}{r} = \frac{GM}{r^2}$ circular orbit ⇒ $v \sim \frac{1}{\sqrt{r}}$; virial theorem; Tot grav. energy : $-\frac{3}{5}\frac{GM^2}{R}$ $\Delta E = \frac{3}{10} G\pi^2 \Delta$

G.R.: Time dilation for spherical BH: $\Delta t_{local} = \sqrt{1-\frac{R_s}{r}}\,\Delta t_\infty$

comoving coordinate r_c ⇒ $D = a(t)\cdot r_c$ $\frac{dD}{dt} = H(t)\cdot D$ $z = \frac{a(t_0)}{a(t_{emit})} - 1$

critical density : $\rho_c = \frac{3H^2}{8\pi G}$ Today: $\rho(t_0) = \rho_c^{(0)}$

QM photons: $E = hf$; $\Delta p \Delta x \geq \frac{\hbar}{2}$ ⇒ degeneracy pressure

Nuclear Reaction in Sun: $p+p \xrightarrow[\text{interaction}]{\text{weak}} p+(n+e^+ + \nu_e) \xrightarrow[\text{IA}]{\text{strong}} d = {}^2_1 0$; $d+p \xrightarrow[\text{I.A.}]{\text{e.m.}} {}^3He + \gamma$; ${}^3He + {}^3He \to {}^4He + 2p$

^{56}Fe

Blackbody energy density : $8\pi \frac{d\nu}{\nu^4} \frac{1}{e^{h\nu/\pi kT}-1} = \frac{8\pi k^4 T^4}{(hc)^3} \frac{dx}{x^4} \frac{1}{e^{\frac{1}{x}}-1}$ tot Eng density $\frac{4\sigma}{c}T^4$

energy density $x = \frac{\nu h T}{hc}$