$g_{\mu\nu}$
$x^{\mu} =$
$ds^2 =$
$g_{\mu\nu}\mathrm{d}x^{\mu}\mathrm{d}x^{\nu}$
$\mathrm{d}x^{\mu}$
$\mathrm{d}x^{\nu}$
$^2 =$
$a^2\left(\frac{\mathrm{d}r^2}{1-kr^2} + r^2\mathrm{d}\phi^2\right)$
k
a
k
k
k
k
$sin\chi$
r
$sinh\chi$
$g_{\mu\nu} =$
$(1, -1, -1, -1)$
$ds^2 =$
$c^2\mathrm{d}t^2 -$
$(\mathrm{d}x^2 +$
$\mathrm{d}y^2 +$
$\mathrm{d}z^2)$
$_{\mu\nu} =$
$\frac{8\pi G}{\rho}T_{\mu\nu}.$
$G_{\mu\nu}$
$T_{\mu\nu}$
$_{\mu\nu} =$
$(\rho c^2, p, p, p),$
ρc^2
p
$ds^2 =$
0
$^2 =$
$c^2t^2 -$
$a(t)^2(\chi^2 +$
$r(\chi)^2\Omega^2)$
$\Omega^2 =$
$\theta^2 +$
$\sin^2\theta\phi^2$
χ
$r(\chi) =$
$f_K(\chi) =$
$\{\sin\chi closed case, positive curvature$
$\chi flat case$
$\sinh\chi open case, negative curvature$
$a(t)$
$s =$
0
$\lambda \approx$
a
$\lambda_{obs}\frac{}{\lambda_{emit} = \frac{a_{obs}}{a_{emit}} = \frac{a_0}{a_{emit}}},$
λ_{obs}
$a_{obs} =$
a_0
λ_{emit}
a_{emit}
$\frac{a_{emit}}{a_0} \leq$
1
$z \geq$
0
$H\dot{a}/a$
H_0
$H_{0} =$
$100h\ ,$
$h \approx$
0.7
$H_0^{-1} \approx$
10
$cH_0^{-1} \approx$
4
$\mathbf{??}$
$^2 =$
$\left(\frac{\dot{a}}{a}\right)^2 =$
$\frac{8\pi G}{3}\rho -$
$\frac{Kc^2}{a^2}Friedmann equation$
$\frac{\ddot{a}}{a} =$
$\frac{4\pi G}{3}\left(\rho + \frac{3p}{c^2}\right)2^{nd}Friedmann equation,$
$\rho =$
$\rho_m +$
$\rho_r +$
ρ_Λ
$\rho_m =$
$\rho_{m,0}\left(\frac{a_0}{a}\right)^3 \approx$
a^{-3}
$\rho_r =$