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