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To date observations have not yet unequivocally determined whether the universe is open or closed. Although for the luminous matter $\Omega \lesssim 0.1$, the possibility of existence of non-luminous matter (especially if the neutrino has a non-zero mass) leaves ground for considering that the universe may indeed be closed. In this case the universe is expected to recollapse and become again, at a time t_o, radiation dominated. Hence $R(t) \sim (t_f - t)^{1/2} \sim 1/T\,(t)$, where t_f is the time of collapse to the singularity and T is the temperature. During this new radiation dominated era, a black hole of mass M_o will accrete at a rate

$$\frac{dM}{dt} \simeq 4\pi\, r^2(t)\, \rho(t)\, c \qquad (1)$$

where $\rho(t) \simeq \alpha T^4(t)$ and $r(t) = 2GM(t)/c^2$. Eq (1) upon integration yields

$$\frac{M}{M_o} = \left[1 - \frac{4\pi r_o^2 \rho_o c\, \tau_o}{M_o} \left(\frac{\tau_o}{\tau} - 1\right)\right]^{-1} \simeq \left[1 - \frac{4\pi r_o^2 \rho_o c\, \tau_o}{M_o} \frac{\tau_o}{\tau}\right]^{-1} \qquad (2)$$

(All subscript zero quantities are taken at $t = t_o$). Eq (2) shows that the mass of the black hole diverges when $\tau_o/\tau \sim M_o/4\pi r_o^2 \rho_o c\tau_o$ where $\tau_o = t_f - t_o$.

For $M_o \simeq 1 M_\odot$, and since $\rho_o \simeq 10^{-19}$ g cm^{-3} ($= aT_o^4$ for $T_o \simeq 1$ ev) and $\tau_o \simeq 10^{13}$ sec one obtains $\tau_o/\tau \sim 10^{16}$. Hence the divergence temperature will be $T \simeq 10^8\, T_o$. Since $T_o \simeq 1$ eV is then $T \simeq 100$ MeV – 1 GeV, i.e the mass diverges at a finite, modest (by early universe standards) temperature at which the micro-physics is well understood. The source of this devergence is the prescribed time dependence of the temperature during recollapse. This certainly breaks down when the radius of the black hole becomes comparable to R. At this point however the universe has irrepairably departed from homogeneity and isotropy, and its reemergence into a new Robertson-Walker cycle seems quite unlikely.

G. O. Abell and G. Chincarini (eds.), Early Evolution of the Universe and Its Present Structure, 331.