PHYS 480/581
Cosmology

Worksheet #14
Monday 10/24/2022

Question 1.

(a) Last week, we computed the effective number of relativistic degrees of freedom $g_*(T)$ by counting the particles with mass $m_i < T$ at each T. This gave us the values of $g_*(T)$ at the plateaus shown in Fig. 1 below. However, $g_*(T)$ is a smooth function of temperature (except maybe at the QCD transition), not a series of sharp steps going down. If you were asked to compute this curve exactly at $T > 200$ MeV, how would you do it? Write down a formal expression for $g_*(T)$ valid at $T > 200$ MeV. You don't need to numerically evaluate your expression.

(b) In Fig. 1 below, the curve splits into two different lines for $T \lesssim 0.5$ MeV (one solid, one dotted). This occurs because $g_*(T) \neq g_{*S}(T)$ at these low temperatures. Compute both $g_*(T)$ and $g_{*S}(T)$ after e^+e^- annihilation and confirm the values shown on the plot for $T \lesssim 0.05$ MeV. Which line shows $g_{*S}(T)$?

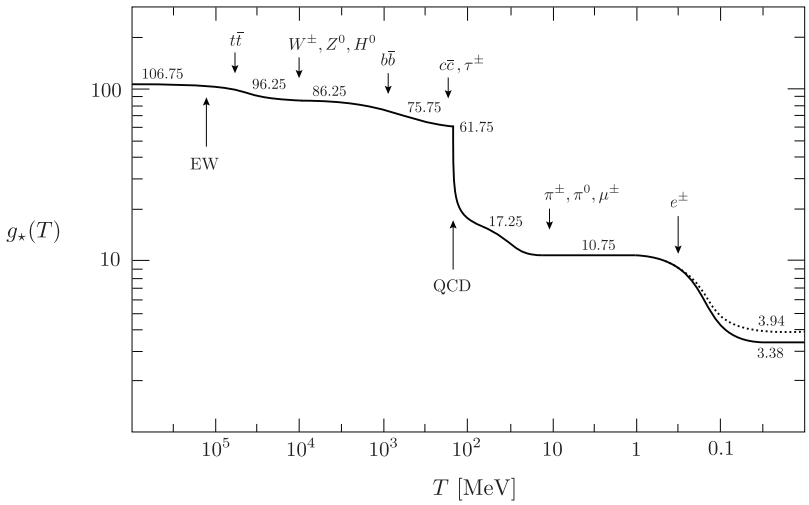

Figure 1: Effective relativistic number of degrees of freedom in the early Universe as a function of temperature. Figure taken from Baumann (2022).