UNIVERSITY OF CALIFORNIA, SANTA BARBARA
Department of Physics
2014 Winter Quarter

GALAXIES AND COSMOLOGY Professor Treu

HOMEWORK #1
EMPIRICAL EVIDENCE FOR THE BIG BANG

Problem 1: **Neutrino mass**
Ryden, Problem 2.4.

Problem 2: **Planck's Law**
Treat the Sun as a blackbody of absolute temperature 5800 K. Use Stefan's law to show that the total radiant energy emitted by the Sun per second is 3.95×10^{26} Js^{-1}. Find the rate at which energy is reaching the top of the Earth's atmosphere. Your answer should have units of flux – J s^{-1} m^{-2}. *Hints: Stefan-Boltzmann constant* $\sigma = 5.67 \times 10^{-8}$ $J\ s^{-1}\ m^{-2}\ K^{-4}$. *The radius of the Sun is* 7.0×10^8 *m, and the Sun – Earth distance is* 1.5×10^{11} *m.*

Problem 3: **Tired light Universe**
Ryden, Problem 2.5.

Problem 4: **When was He formed?**
Assuming that the size of a He nucleus is 2 Fermi (10^{-15}m), estimate the epoch of He formation in a Big Bang cosmology, expressed in redshift and temperature. *Hint: order of magnitude estimate is sufficient.*

Problem 5: **Hot Dark Matter**
Assuming dark matter is in the form of massive neutrinos (of approximately equal mass), that the total mass density of the universe is 1 in critical units, and there is no dark energy, compute the required neutrino masses in eV.