

# Astrophysik II: Galaxien und Kosmologie

WS17/18  
problemset 11

24.01.2018

## **Aufgabe 1.** *Plancks law of radiation*

We derive Plancks law of black body radiation  $u(\nu, T)$  using the Einstein-coefficients  $B_{01}$  (induced absorption),  $B_{10}$  (induced emission), and  $A_{10}$  (stimulated emission).

- (a) Draw a two level system and overplot the three mentioned processes.
- (b) Derive the occupation inversion of this two level system. Hint: Do not forget that each energy state could be degenerate by a factor of  $g$ .
- (c) Use the Taylor-expansion for the exp-function and compare with the Rayleigh-Jeans limit ( $u(\nu, T) = (8\pi\nu^2/c^3) \cdot kT$ ) to derive a relation between  $A_{10}$  and  $B_{10}$ . Hint:  $g_0 B_{01} = g_1 B_{10}$ , why is that?
- (d) Now derive Plancks law of radiation.

## **Aufgabe 1.** *Short questions*

- (a) Explain the general difference between Bosons and Fermions. Do you understand the result of problem 1, physically?
- (b) Integrate Plancks law to obtain Stefan-Boltzmann law for black body radiation.
- (c) Calculate the position of the maximum of Plancks law (derive Wiens law).
- (d) Explain the anisotropies regarding the CMB.
- (e) What are the major differences between the black body spectrum of the CMB and the spectrum of the sun?