

1. Suppose we have a species with two non-degenerate levels, to which we will refer as u (upper) and ℓ (lower), separated by an energy $E_{u\ell}$. The Einstein coefficient for spontaneous transitions from state u to state ℓ is $A_{u\ell}$. At time $t = 0$, all of the atoms are in state u . The density is low enough that collision-induced transitions between u and ℓ are negligible, and there is no background radiation field.
 - (a) What fraction of the atoms are in each of the two states at time t ? What is the limiting behaviour as $t \rightarrow \infty$?
 - (b) Suppose that the atoms are bathed in a thermal radiation field at temperature T . Now what is the fraction of atoms in each state as a function of t . What is the limiting behaviour as $t \rightarrow \infty$?
2. The most abundant species of carbon in the ISM is C^+ , which has five electrons.
 - (a) Write down the electronic state.
 - (b) Write down the possible L-S coupling states corresponding to this electronic state.
 - (c) Which L-S coupling state is the ground state?