

15 A collection of small problems for oral examination held on Sep 18th (13:00 -)

- 1) There are various energy levels of a Hydrogen atom; e.g., $Ly\alpha$ etc, radio recombination lines, fine structure lines, hyper fine structure lines, and Zeeman splitting. Please explain these energy levels and compare their energies using a fine structure constant, $\alpha = 1/137$.
- 2) Please explain the quantum numbers of photon, quantum states of single photon and photon fields, e.g., in terms of Bose statistics or Hamiltonian of Photon.
- 3) Under what conditions can an electron(s) emit photon(s)?
- 4) Why did Dirac introduce his famous Dirac equation for describing electron's quantum states etc.? What are outcomes from the Dirac equation?
- 5) Please explain a "transition moment", and allowed and forbidden transitions. How can a "transition probability" for some transition be expressed?
- 6) Please explain what spontaneous and stimulated emissions are in terms of Einstein's A and B coefficients. Please describe a rate equation for a simple two energy state case.
- 7) Please introduce yourself and your research; e.g., talk about why you are studying astronomy, what your main interest is, what your main theme in your master thesis is, etc.
- 8) What kind of information can be obtained from "CO SEDs" for galaxies?
- 9) Please explain the selection rule for $NH_3(1, 1)$ transitions shown in the figure (neglect I_N here).
- 10) Please estimate critical densities for $CS(J = 7 - 6)$ and $HCN(J = 4 - 3)$ using the equation given in the lecture note.
- 11) Please describe about the rotation of interstellar dust grain and its alignment to interstellar magnetic field.
- 12) Please explain the Purcell's discussions on a limit to a gas-to-dust ratio and dust emissivity index β .
- 13) How can the radiative equilibrium of the Earth be expressed?
- 14) There is a dipole anisotropy of CMB with a level of $\Delta T/T \pm 0.3\%$. What can cause the dipole?
- 15) How is a star formed in our galaxy? Please explain using words, molecular cloud, dense core, gravitational collapse, free-fall time, Jean's mass.
- 16) Why is it pointed out that the star formation in our galaxy is "slow"?
- 17) What kinds of emission can be used to estimate SFR? What are pros and cons of the SFR tracers?

Note:

- 5 - 10 smaller problems (e.g., "What is a wavelength of $Ly\alpha$?") will be added.
- You can two chances to take problems from 1) - 17) by means of drawing cards showing only number of problems.
- If you have questions and comments, please contact me via e-mail (ryo.kawabe@nao.ac.jp).

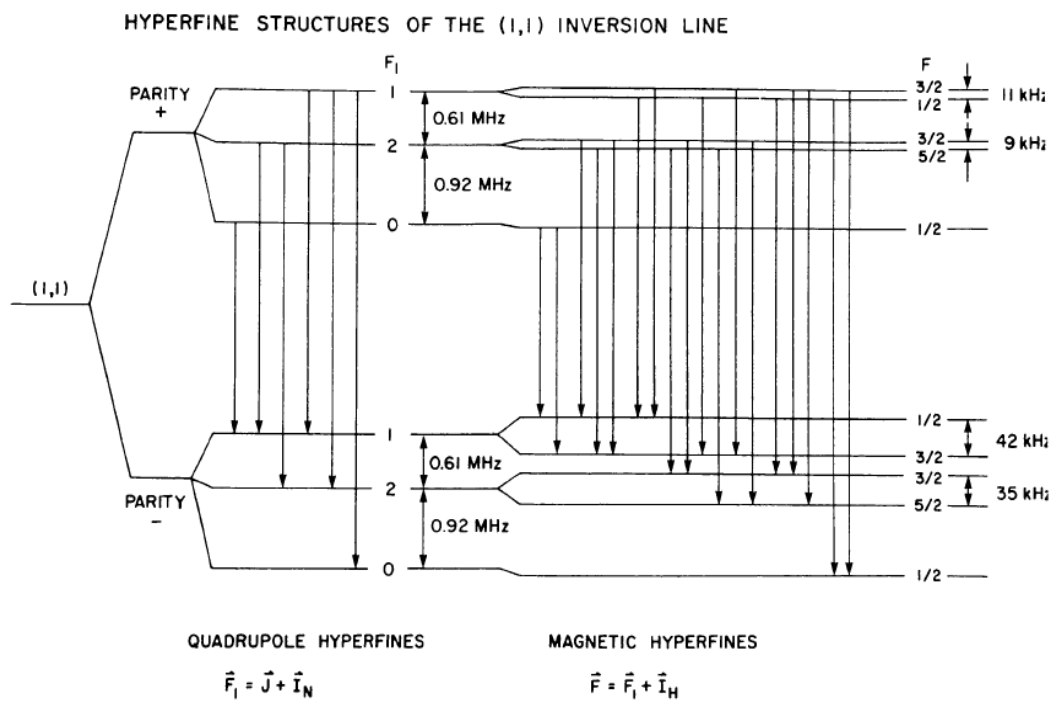


Figure 53: Hyperfine splitting of the $(J, K) = (1, 1)$ rotational inversion transition from Ho and Townes (1983). The allowed transitions are indicated.