	INDIAN INSTITUTE OF TECHNOLOGY PATNA **DEPARTMENT OF PHYSICS** **TUTORIAL 1**
31/01/2019	**PH603 PHYSICS OF ULTRACOLD ATOMS**

Problems

1	An atom moving in a counter propagating direction to light field see the Doppler shifted light frequency as a. Red shifted b. Blue Shifted c. At resonance d. No effect
2	The heating rate observed in MOT is due to a. Stimulated emission b. Spontaneous emission c. Stimulated absorption d. Atomic Collisions
3	Which of the following configuration will work in a MOT for red detuned counter propagating light beams ? A. Sigma- and Sigma+ (-B to +B) b. Sigma+ and Sigma- (+B to –B) c. Sigma- and Sigma+(+B to –B) C. Lin and Sigma – (+B to –B)
4	Laser cooling force is due to a. Resonant effect b. Non Resonant effect c. Non-linear effect d. Raman effect
5	In the Optical Molasses stage and MOT stage a. Same frequency ramp is done b. No frequency ramp done in MOT stage c. different frequency ramp is done d. No frequency ramp done in Optical Molasses stage
6	MOT works as a. Magnetic trap + laser cooling for atoms b. Light trap + Magnetic forces c. Space selective laser cooling using Zeeman effect and proper light polarizations d. Magnetic fields are used to change light polarization for cooling
7	Effective red detuning required for a co-propagating beam in MOT ($\Delta = \omega_L - \omega_0$) a. $\Delta + kv + b'x$ b. $\Delta - kv + b'x$ c. $\Delta - kv - b'x$ d. $\Delta + kv - b'x$
8	In an optical molasses using red detuned beams co-propagating beams has the following expression for Force ($\mathbf{F_{co\text{-}prop}}$) a. $\mathbf{F_0} + \frac{\alpha}{2}\mathbf{k}v$ b. $\mathbf{F_0} - \frac{\alpha}{2}\mathbf{k}v$ c. $-\mathbf{F_0} + \frac{\alpha}{2}\mathbf{k}v$ d. $-\mathbf{F_0} - \frac{\alpha}{2}\mathbf{k}v$

9	Find out the Single-photon recoil velocity and recoil temperature for Sodium atom [Mass of Na atom is 22.98 a.m.u, Resonant wavelength = 589.3 nm]
10	An ensemble of two level atoms moving at a room temperature of 300K needs to be laser cooled and trapped in an experiment. Assume average atomic speed inside the Vacuum chamber as 300m/s. Being an experimentalist in Quantum Optics, think of implementing this in a set up (a) How will you achieve the appropriate detuning for the laser experimentally for cooling process? (a)What will be the experimental parameters you need to set for Optical Molasses stage and MOT stage given the Magnetic field numerical value changes from +0.5G to -0.5G along the periphery of the laser cooling beam in an anti-Helmholtz configuration. Magnetic field gradient is very small and negligible (Band gap Wavelength for this atom 750 nm) (b). Sketch the Experimental sequence of Optical Molasses stage and MOT stage assuming optimum time scales of frequency ramp as 5 ms for each stage. {Use F = 0 to F = 1 as ground and excited states, for simplicity choose g_f = 1 for F = 1 level of the hypothetical atom}

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