HOMEWORK SET 1

Tutorial Lectures on Spintronics

Jaroslav Fabian, University of Regensburg

1. *Drift-diffusion with traps and recombination.* Analyze the one dimensional random-walk model and obtain the drift-diffusion and continuity equations in the following two cases:

i) A single particle species undergoes random walk in the presence of traps in which the particles can disappear with the probability of w per the time of flight. (Think of a drunkard passing over open manholes when going home from a pub. There is a chance he or she will be permanently removed by falling into one).

ii) Two particle species, electrons with the density n and holes with the density p, undergo random walk. Suppose that an electron can recombine with a hole with the probability of $r \ll 1$ per the time of flight per a single hole (the probability increases if there are more holes present). Suppose that there is also a thermal generation of electron-hole pairs, giving a steady rate of generation rn_0p_0 per time flight. What is the physical meaning of n_0 and p_0? This model describes the transport of electrons and holes (called bipolar) in semiconductors such as GaAs.

2. *Electric field effects in spin drift-diffusion.* Solve the steady-state spin drift-diffusion equation in the presence of an electric field. As boundary conditions use $s(x = 0) = 0$ and $s(x \to \infty) = 0$. How does the spin diffusion length modifies as the field increases? At which values of the field would the electrical field effects become important? Use typical materials parameters for metals and nondegenerate semiconductors. For the spin-injection boundary condition, $J_s(x = 0) = J_{s0}$, how does the spin accumulation change if the electric field is oriented in the x direction? How does it change if the direction is opposite?