# Electrically Induced Raman Emission from Planar Spin Oscillator

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Optical pumping with anisotropic light has long been studied in atoms and semiconductors to induce magnetic polarization or inversely to obtain circularly polarized light from the recombination of a spin polarized current. Light emission from pure magneto-dipole coupling has comparatively been difficult to demonstrate in the solid state despite arising naturally elsewhere, for example in clouds of galactic dust[1]. One way for the electron spin to gain energy is by traversing a region of spatially inhomogeneous magnetic field. Due to advances in micro-fabrication such magnetic modulations can now be applied to low-dimensional electron systems[2]. Hybrid confinement by electrostatic potentials and magnetic field gradients introduces an artificial means of coupling the spin and orbital motion to induce spin resonant effects impossible to obtain through conventional spin-orbit coupling[3,4].

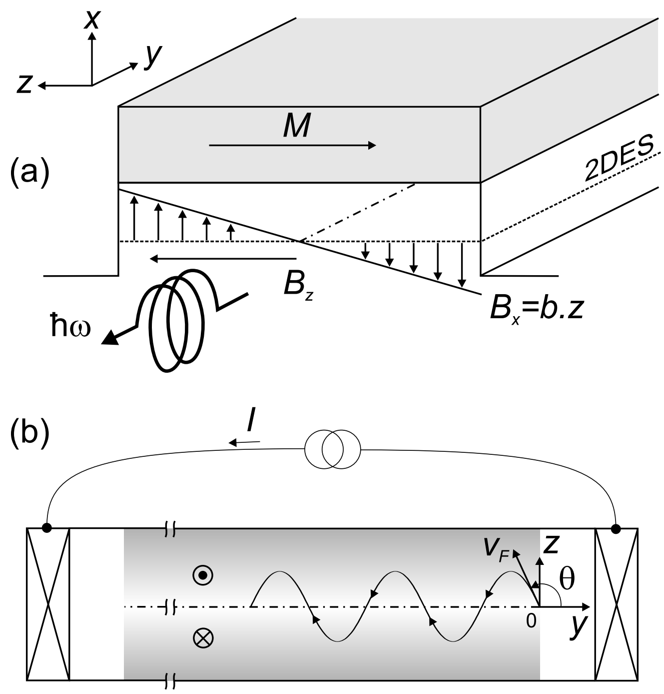


**Figure 1:** (a) Magnetic waveguide cross-section. (b) A spin polarised current is injected into the 2D electron system (2DES) through magnetic contacts magnetized along *z*. The 2DES section located below the ferromagnetic wire is subjected to both a magnetic field gradient from the stray vector component $B_x$ (amplitude≡level of gray) that channels electrons in open orbits and a constant $B_z$ that sets the spin Larmor frequency.

In this paper, I shall demonstrate the generation of electromagnetic radiation through the process of inverse electron spin resonance. This is realised when a spin ½ charged particle is confined to a plane and subjected to both an in-plane homogeneous magnetic field and a perpendicular magnetic field gradient as shown in Fig.1a. Particles drifting in open orbits, near a line of zero transverse magnetic field have an oscillatory motion that subjects the spin magnetic moment to a periodic magnetic field. Energy is then resonantly transferred to the electromagnetic field when the frequency of an open orbit equals the Larmor frequency. The electromagnetic emission spectrum is calculated and is found to peak near the cut-off frequency of the open orbits. The amplitude and helicity of light are respectively controlled by the current intensity and the spin polarization of the injected current as shown in Fig.1b. The position of the emission lines only depends on the magnetic field gradient, the electron effective mass and the electron concentration. The range of values taken by these parameters indicates that emission lines are tunable in the 0-500GHz range. This anisotropic light source is therefore well suited to the manipulation of nuclear spins in quantum computation[5]. Magnetic waveguides could be biased with current pulses of calibrated amplitude and duration to tip nuclear spins underneath the 2D electron system.

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