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Spin-orbit ferromagnetic resonance

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In conventional magnetic resonance techniques the magnitude and direction of the oscillatory magnetic field are (at least approximately) known. This oscillatory field is used to probe the properties of a spin ensemble. Here, I will describe experiments that do the inverse [1]. I will discuss how we use a magnetic resonance technique to map out the current-induced effective magnetic fields in the ferromagnetic semiconductors (Ga,Mn)As and (Ga,Mn)(As,P). These current-induced fields have their origin in the spin-orbit interaction [2-4]. Effective magnetic fields are observed with symmetries which resemble the Dresselhaus and Rashba spin-orbit interactions and which depend on the diagonal and off-diagonal strain respectively. Ferromagnetic semiconductor materials of different strains, annealing conditions and concentrations are studied and the results compared with theoretical calculations. Our original study measured the rectification voltage coming from the product of the oscillatory magnetoresistance, during magnetisation precession, and the alternating current. More recently we have developed an impedance matching technique which enables us to extract microwave voltages from these high resistance (10 kΩ) samples [5]. In this way we measure the microwave voltage coming from the product of the oscillating magneto-resistance and a direct current. The direct current is observed to affect the magnetisation precession, indicating that anti-damping as well as field-like torques can originate from the spin-orbit interaction.

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