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Direct observation of spin polarization in GaAs quantum wires by transverse electron focusing

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Abstract. We present transverse electron focusing measurements in the two dimensional electrons gas formed at the interface of a GaAs/AlGaAs heterostructure. The experimental arrangement consists of two orthogonal quantum point contacts (QPCs), one acting as injector and the other as detector of the collimated 1D electrons as a function of transverse magnetic field. The focusing spectrum shows anomalous behaviour, the first and third focusing peaks split into two sub-peaks while second peak remains as a single peak. The observed splitting, a signature of spin states, arises from the spin-orbit interaction when the 1D electrons are injected into the 2D regime, thus allowing us to manipulate the spin states within the 1D channel.

There is considerable interest in the spin properties of clean one-dimensional (1D) quantum wires, the science of which has potential for spintronics and spin-based logic devices. Generally electrons in a quantum wire are spin degenerate, but spin polarisation becomes observable on the application of a large in-plane magnetic field[1]. Although spontaneous spin polarisation is forbidden in a strictly 1D system of infinite length, according to the Lieb-Mattis theorem[2], phenomena attributed to spin polarisation[3, 4] such as the 0.7 anomaly[1, 5, 6] and source-drain bias induced 0.25 structure[7] have been observed in quasi-1D systems. A direct measurement of the degree of spin freedom is thus necessary to lead to a comprehensive understanding of these features to complement conductance measurements[8].

A typical transverse electron focusing setup consists of an injector and a detector, generally along a plane such that on application of a small perpendicular magnetic field ($B_\perp$) the electrons will exhibit cyclotron motion[9, 10]. Once the cyclotron radius (r_c) matches the condition $N\times 2r_c=L$ (N is an integer and L is the separation between the injector and detector), the injected electrons are guided into the detector and result in a voltage drop across the detector (refered as V_{cc} hereafter). The cyclotron radius is directly proportional to $B_\perp$, thus giving rise to focusing peaks periodic in $B_\perp$.

It has been predicted theoretically[8] that an imbalance of the spin-split branches, due to the spin-orbit interaction, can be detected using transverse electron focusing by means of observation

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