Measuring the size of single-electron wavepackets using a beam-chopping technique

J. D. Fletcher [1], M. Kataoka [1], H. Howe [2], M. Pepper [2], P. See [1], S. P. Giblin [1], J. P. Griffiths [3], G . A. C. Jones [3], I. Farrer [3], D. A. Ritchie [3], and T. J. B. M. Janssen [1]

[1] *National Physical Laboratory, Hampton Road, Teddington, Middlesex TW11 0LW, UK*
[2] *London Centre for Nanotechnology, and Department of Electronic & Electrical Engineering, University College London, Torrington Place, London, WC1E 7JE, UK*
[3] *Cavendish Laboratory, University of Cambridge, J. J. Thomson Avenue, Cambridge CB3 0HE, UK*

Single electron sources defined in confined semiconductor systems allow precise charge transfer rates [1]. The ability to control the emission time of single electron excitations allows us to mimic the interferometers and probes of quantum optics, and perhaps even use electrons as carriers of quantum information [2]. The electron energy and emission time distributions are key features of clock-controlled electron sources, but are yet to be established and controlled. We have developed a time-domain 'beam chopping' probe of single electron excitations from a two-gate electron pump, defined in GaAs 2DEG [1] (Fig. 1a). We operate at high magnetic field (B = 12 T) in the quantum Hall regime where electrons can travel ballistically along edge channels with reduced inelastic scattering [3]. Three microns away from the pump we use a third barrier to probe the electronic distribution in the time-domain, modulating this barrier at the pump frequency, but with an adjustable phase shift (Fig 1b). The current passing the detector barrier I_c depends on the overlap of the electronic excitations with the time dependent transmission probability. By studying the variation of I_c with delay time (Fig 1c) and assuming a model electronic distribution we estimate the wavepacket length (which includes both emission broadening and dispersion) to be only 80 ps. We show that this is actually short enough that multiple electrons emitted in the same pump cycle can be distinguished and routed into different device leads.

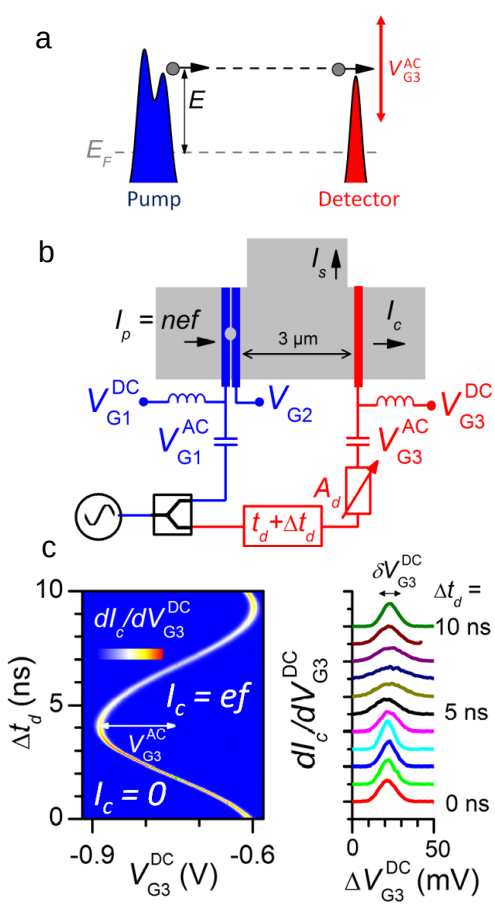

Fig 1.

[1] S. P. Giblin *et al.* Nat. Comm. **3**, 930 (2012).
[2] E. E. Bocquillon Phys. Rev. Lett. **108**, 196803 (2012).
[3] D. Taubert *et al.*, Phys. Rev. B **83**, 235404 (2011).