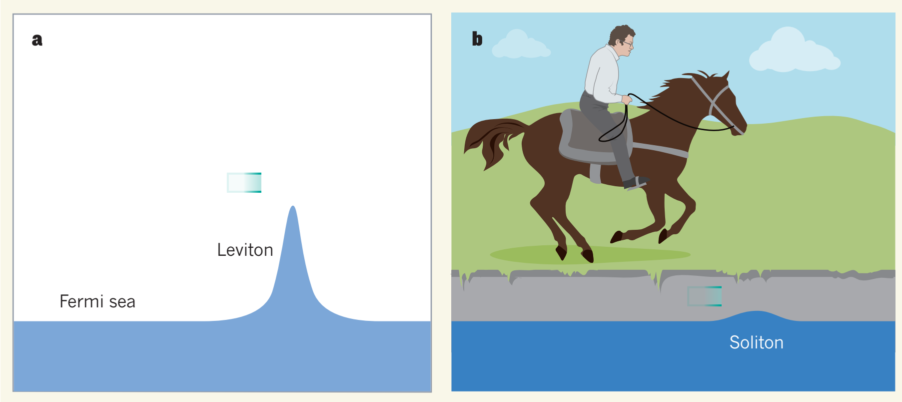


**Figure 1 | Spotting solitons and levitons.** **a**, Dubois *et al.*[1] have experimentally realized Levitov and colleagues' proposal[2–4] that a carefully engineered voltage pulse would bring just a single electron to the top of the Fermi sea of electrons in a nanoelectrode; they have named the resulting single-electron wavepacket a leviton. **b**, Levitons resemble solitons, waves that keep their shape while travelling at constant speed and which were first observed in Edinburgh's Union Canal by John Scott Russell while on horseback.

sea, leaving no traces behind. This job would be done by a voltage pulse that changes in time according to the mathematical function called a Lorentzian.

In their experiment, Dubois *et al.* realize the proposal by Levitov and colleagues, and they name the resulting single-electron wavepacket a leviton, because it resembles a soliton in certain ways. Solitons were first observed in the nineteenth century by the Scottish engineer John Scott Russell who noticed that a boat brought to a sudden stop in the Union Canal running into Edinburgh generated a single, localized wave of water that travelled several kilometres without changing its shape or slowing down (Fig. 1). Such self-sustained waves are now known as solitons, and they occur in a variety of systems described by non-linear wave equations.

Just like solitons, levitons of different heights, widths and creation times can be superimposed in a controllable manner and travel unhindered on top of a Fermi sea. To produce levitons, Dubois *et al.* used a nanoscale circuit consisting of two electrodes connected by a small conductor. They applied Lorentzian-shaped voltage pulses on one electrode to generate levitons that travel through the conductor to the other electrode.

Whereas Russell observed solitons in the Union Canal from the back of his horse, the observation of levitons requires sophisticated experimental techniques. To observe them, the temperature must be as low as it can get to make the Fermi sea as quiet as possible. Dubois and colleagues managed to cool their sample down to 35 millikelvin, close to absolute zero. A sequence of Lorentzian-shaped pulses should yield a noiseless flow of levitons without electrical fluctuations[2–4]. The authors measured the electrical noise[5] and found only the background noise caused by tiny thermal fluctuations. Next, they used a narrow constriction in the conductor — a quantum point contact — to filter out a fraction of the levitons. By measuring the increased noise due to the filtering, they could infer the number of emitted levitons and demonstrate that each pulse produces exactly one leviton, with no additional disturbances.

To corroborate their findings, the research team performed a Hong-Ou-Mandel experiment known from optics[6]. Here, a semi-transparent mirror randomly reflects or transmits photons into two different output arms. However, if two identical photons simultaneously hit each side of the mirror, they always exit into the same output arm. The photons are said to 'bunch', as is typical for the class of particles called bosons. Levitons, by contrast, are fermions, which 'anti-bunch' by exiting into different output arms[7]. Dubois *et al.* generated levitons in both electrodes and caused them to interfere at the quantum point contact, which acts as a semi-transparent mirror. Levitons arriving simultaneously at the quantum point contact were found to anti-bunch, confirming their fermionic nature.

Dubois and colleagues' work demonstrates unprecedented control of single electrons in the Fermi sea of a nanoelectrode, and it opens up a plethora of applications and directions for fundamental research. One can envisage future quantum electronics with levitons — levitonics — in which single levitons are emitted into a circuit architecture with edge states (formed in a strong magnetic field) that function as rails for the levitons by guiding them to beam splitters and interferometers for further processing, borrowing ideas and concepts from quantum optics.

Additional experiments might investigate the statistical properties of levitons, including the fluctuations in the number of levitons (full counting statistics[8]) and the distribution of waiting times between levitons[9]. A leviton can contain more than one electron and may even carry just a fraction of the electron charge if implemented in a one-dimensional system

NATURE

## 50 Years Ago

During the past year, reports of a remarkable case of 'digital vision' have percolated into Britain from the U.S.S.R. … The subject … whose personality is admittedly abnormal, is said to have trained herself to distinguish colours and forms by means of her fingers and to be able to read books and newspapers by digital scanning alone … It has been shown, for example, that her reading is not impaired by interposing a plate of glass between the print and her fingers or by projecting the print on to a ground glass screen to exclude tactile sensation. It might, therefore, seem that the girl's fingers are genuinely sensitive to light … The lack of any image-forming device and the relative poverty of the nerve supply to the fingers in comparison with that of the eye constitute seemingly fatal objections to the hypothesis of 'digital vision'.
**From *Nature* 2 November 1963**

## 100 Years Ago

*Vorlesungen über die Theorie der Wärmestrahlung*. By Dr. Max Planck — The first edition of this book, which appeared in 1906, was reviewed in Nature … The many and varied contributions to our knowledge of radiation phenomena that have been published in the ensuing years have made it necessary for Dr. Planck to rewrite and modify the book to a considerable extent … As before, the object of the book is to apply the statistical methods previously used in the kinetic theory of gases to the phenomena of radiation … The treatment is largely based on the remarkable assumption which the author designates as the "quantum-hypothesis." … This is analogous to the electron theory, which assigns a definite magnitude to the electron or "elementary quantum" of electricity.
**From *Nature* 30 November 1913**