as the magnetization direction changes with respect to the lattice, also causing shifts of the Fermi energy. This shift is then compensated by an electrostatic potential that affects the electrostatic potential of the dot. Hence, magnetization rotation acts similarly to a gate voltage and allows tuning of the conductance through the quantum dot.

The demonstration by Bernand-Mantel *et al.* highlights the potentially important role ferromagnetic contacts can have in the development of nanoscale electronics, and illustrates how the magnetic anisotropy of certain materials can be used to induce magneto-Coulomb effects. This is related to recent experiments in which transport across quantum dots made of the ferromagnetic semiconductor (Ga, Mn)As were investigated[6,7]. In these experiments, several islands, instead of a single one, were involved in transport. In contrast with the experiment of Bernand-Mantel *et al.*, it is the magnetization direction of the ferromagnetic dots rather than the magnetization direction of the leads that matters. However, in these experiments tuning the magnetization direction also has the same effect as tuning a nearby gate voltage. Accordingly, the magnetization of ferromagnetic constituents of single-electron transistors comprises an extra degree of freedom for adjusting the island's potential and for tuning the conductivity.

Nearly two decades after the introduction of the single-electron-transistor concept (ref. 8 and references therein), the emergence of ferromagnetic electrodes and nanoparticles represents a new twist in its development and gives a boost to the emerging field of single-electron spintronics. ❐

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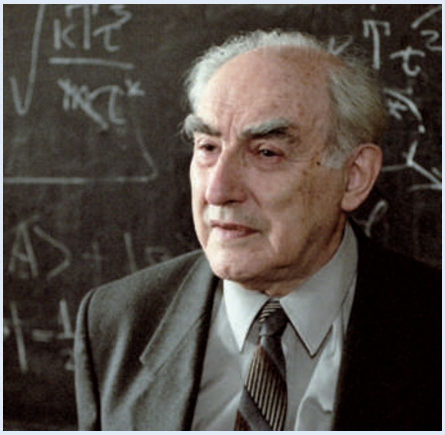
VITALY LAZAREVICH GINZBURG

The legacy lives on



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Vitaly Lazarevich Ginzburg (pictured) has died, aged 93. In life, he was celebrated for his numerous achievements to several areas of physics. Moreover, like many towering scientists of a bygone age, he was an active citizen who made lasting contributions to life in his country, well beyond the realm of physics or even science. In the 1990s, during the declassification of Soviet intelligence files, we learned of his part in the development of the hydrogen bomb for the Soviet Union. Ginzburg himself said that this activity probably saved him from the firing squad (or at least from unemployment) around the time of the 'doctor's plot', a period in which a "totally insane" Stalin accused a number of doctors, more than half of whom were Jewish, of plotting to kill top government officials.

Despite his fame in plasma physics and astrophysics, not to mention nuclear physics, his greatest legacy is the Ginzburg–Landau theory of superconductivity. The Ψ-theory, as he called it, predates the microscopic Bardeen–Cooper–Schrieffer (BCS) theory of superconductivity and is a triumph of physical intuition and ingenuity. Incidentally, having been born in 1916, Ginzburg had a rather unconventional education owing to the First World War and its aftermath, only managing four years of formal schooling before gaining entrance to Moscow State University by open examination. Perhaps his unorthodox path is the reason why his approach to superconductivity is so intuitive and practical — a true workhorse theory for students not necessarily versed in second quantization and other advanced theoretical gymnastics required for BCS.

But back to Ginzburg–Landau theory. It is essentially based on Lev Davidovich Landau's theory of type-II phase transitions applied to a charged fluid; technically, it introduces a gradient term that couples to the vector potential and allows for a complex wavefunction. Without any knowledge of the microscopic structure (that is, the existence of paired electrons), it is possible to write down the free energy of the system. When minimized, two equations emerge. The first looks like a Schrödinger equation plus a nonlinear term, heralding some kind of macroscopic wavefunction Ψ, or coherent behaviour. The second equation is identical to the quantum mechanical definition of current. These two expressions, together with Maxwell's equation for magnetic field, lead to the following: (i) the magnetic screening (Meissner effect) and critical magnetic field above which the superconductor is no longer superconducting; (ii) the extent to which the magnetic field can penetrate the surface (penetration depth λ); (iii) the first London equation (which leads to the supercurrent, or electrical flow without resistance); (iv) the coherence length (ξ) of the wavefunction; (v) flux quantization; and (vi) the vortex lattice, in which the vortices through which magnetic flux can penetrate the superconductor are arranged geometrically. In a nutshell, this descriptive theory yields all the properties of a superconductor, except for the transition temperature and superconducting gap structure. And remarkably, it works as well for conventional superconductors as it does for high-temperature superconductors.

His recognition by the Nobel foundation came late in life, when he was 87, but Ginzburg's achievements have been appreciated by working physicists for decades, and will continue to be for the foreseeable future.

MAY CHIAO