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Vitaly Ginzburg: The Last Classical Physicist

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(Guest Editorial)

It is a great honor and responsibility to be Guest Editors for the special issue of *Ferroelectrics*, dedicated to the 90th Birthday of Nobel Prize Winner Prof. Vitaly Ginzburg. We have entitled our Guest Editorial "The Last Classical Physicist" because his creative work practically covers all regions of the modern physics: astronomy, astrophysics, cosmic rays, high spin elementary particles, quantum electrodynamics, solid state physics, including superconductivity and superfluidity, superdiamagnetism and ferrotoroics, crystallooptics and last (but for this journal not least) the theory of ferroelectricity and soft mode conception. Ginzburg often says that Landau was born too late: quantum theory and relativistic physics were almost completed when Landau started as a scientist. Ginzburg is eight years younger than Landau. One can, say, that Ginzburg and Feynman worked "on the tail of the physics revolution." But the universal character of their interests and discoveries permit one to consider them as classicists.

The phenomenological theory of ferroelectricity was born on July 31, 1945, the day that the Editorial Board of the *Journal of Experimental and Theoretical Physics* (JETP) received the paper entitled "Dielectric properties of Ferroelectrics and Barium Titanate," which was written by Ginzburg after preliminary discussions with Landau. In this paper, Ginzburg, using the Landau theory of the second order phase transition, developed a theory of the ferroelectric phase transition of the second order that was also applicable to transitions of the first order in the vicinity of a thermodynamic critical point (Curie critical point in the old terminology). This paper explained the experimental results, obtained in 1945 by Vul and Goldman in the same Institute (Lebedev Physics Institute of the Soviet, now Russian, Academy of Sciences, where Ginzburg began his work in 1938, and is still working). Later, in 1949, Ginzburg published two more well known papers, where he extended the scalar theory, which applied to a strictly uniaxial polarization, a vector formulation valid for the more complex polarization states in the case of $BaTiO_3$ and the many perovskite ferroelectrics discovered since.

In 1949 A. F. Devonshire independently developed essentially the same approach to the $BaTiO_3$ dielectric properties, but omitted some important invariants with P^6 (P is the order parameter) necessary in the case of a first-order transition. Devonshire cited the Ginzburg paper of 1949 and his manuscript came to *Philosophical Magazine* almost one year later.

Ginzburg's conclusion, that the ferroelectric phase transition in $BaTiO_3$ takes place in the vicinity of the critical Curie point could not be confirmed experimentally at that time. Later it was shown that this conclusion is correct, but the critical point, which occurs at high pressures, was not demonstrated experimentally until it was discovered in SbSI in 1968 and even later in $BaTiO_3$. What is most remarkable, perhaps, is how enduring and versatile is the formalism established in Ginzburg's two brief papers, even after the passage of six decades of intensive experimental research on wide range of ferroic systems and the development of increasingly sophisticated theories.

The connection between the ferroelectric phase transition and lattice dynamics and conception of soft mode was developed by Ginzburg in the above mentioned two articles published in 1949. It was done in frame of phenomenological mean free theory. Nevertheless the formulas obtained by Ginzburg for dispersion of the dielectric constant $\varepsilon = \varepsilon\ (\omega,T)$, in the ferroelectric and paraelectric regions were absolutely correct for small frequencies or at the softening of the optical mode. He also predicted the possibility of the connection between the soft mode conception and high temperature superconductivity. The microscopic approach to the soft mode problem was undertaken by Cochran and Anderson much later.

Ginzburg, with coworkers, investigated the influence of the order parameter fluctuation on the Landau phase transition theory. It was shown, that the region near to the structure phase transition temperature, where the Landau approach is not valid, could be very narrow and almost disappears at tricritical point.

In the Soviet Union, Ginzburg many times was refused permission to go abroad. In free Russia going abroad is no longer a problem. The international ferroelectric community was very happy to welcome Professor Ginzburg to the 10th International Conference on Ferroelectricity in Madrid in 2001. Two years later he visited Stockholm to share the Nobel Prize for theory of superconductivity, developed by him with Landau.

There is no need to write about the bright personality, modesty and active social position of Ginzburg. They are well known to everybody, who worked with him or discussed with him any problems. We salute him and wish him many more years of fruitful work and happiness.

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