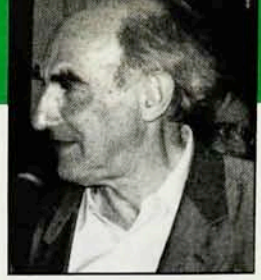


WHAT PROBLEMS OF PHYSICS AND ASTROPHYSICS SEEM NOW TO BE ESPECIALLY IMPORTANT AND INTERESTING?

Vitaly L. Ginzburg

Many people have probably noticed that young physicists, even talented ones, often have very narrow horizons. Such a physicist may be familiar with minute details in some rather sophisticated field, say, quantum field theory. But if you ask the very same physicist about the nature of superconductivity or ferroelectricity, about the structure of a neutron star or a possible way of detecting gravitational waves, you won't get an answer. Meanwhile it does not take much time to acquaint oneself with these and many other topics. Moreover, I hardly need to prove that breadth of views and knowledge is not only natural to the physicist—after all, isn't physics attractive?—but also exceedingly important for successful work; even pure pragmatists should seek such breadth.

It would be out of place to discuss here how young physicists have come to be so specialized and what is generally to be done to change the situation and to fill the gaps in their knowledge. However, in one attempt to achieve that goal I organized and gave special additional lectures for students, and in 1971 I published the paper[1] under the same title as the present column. My 1971 paper listed about 20 problems that I then thought of as particularly "hot." I gave brief remarks and a list of references for each. Since this paper was intended mainly for beginners, I explained in detail things that were absolutely obvious to experienced physicists. Specifically, I strongly emphasized the conditional and subjective character of any list of "especially important and interesting problems" and the impossibility of studying only those problems. At the same time, I am sure that there are some problems that are distinguished by their potential importance for engineering and technology, by their mysteriousness and so on. Still, one cannot embrace everything, and for educational purposes and expanding one's horizons it is absolutely imperative to have a limited range of questions.

I don't know how young physicists reacted to my paper and its subsequent revised versions (discussed below). As for my colleagues, they in general showed no enthusiasm. I shall not repeat here the reproaches I heard at that time, but among those I did not happen to hear, one must have been that my list ignored the particular problems on which individual critics work. To them, this implied that the list was deficient. An older friend of mine once said, "If you had published the paper before you were elected to the Academy of Sciences, you would have never become an academician." Perhaps he was right.

In any case, I continued to compile and discuss my list. Thus the paper became a small book, which was then translated into several languages. The last English version was published[2] in 1985 (although it was ready for publication in 1981). Now I have prepared a new Russian version. (I am afraid it will not appear before 1991.) Each time I revised and updated the text, which was a necessary task but introduced some shortcomings.

My current list of "especially important and interesting problems" is as follows:

▷ *Macrophysics*

1. Controlled nuclear synthesis.
2. High-temperature superconductivity; superdiamagnetism.
3. New substances (creation of metallic hydrogen and other substances).
4. Certain problems of solid-state physics.
5. Second-order and similar phase transitions (critical phenomena); interesting examples of such transitions.
6. Surface physics.
7. Liquid crystals; the study of very large molecules.
8. The behavior of matter in very strong magnetic fields.
9. Rasers, grasers and ultrahigh-power lasers.
10. Strongly nonlinear phenomena (nonlinear physics).
11. Superheavy elements (supertransuranic elements); "exotic nuclei."

▷ *Microphysics*

12. Particle mass spectrum; quarks and gluons; quantum chromodynamics.
13. Unified theory of the weak and electromagnetic interactions; $W^{\pm}$ and Z^0 bosons; leptons.
14. Grand unification; proton decay; the neutrino mass; magnetic monopoles; superunification; superstrings.
15. Fundamental length; high- and superhigh-energy particle interactions.
16. Nonconservation of *CP* invariance; nonlinear phenomena in vacuum and in superstrong magnetic fields; phase transitions in vacuum.

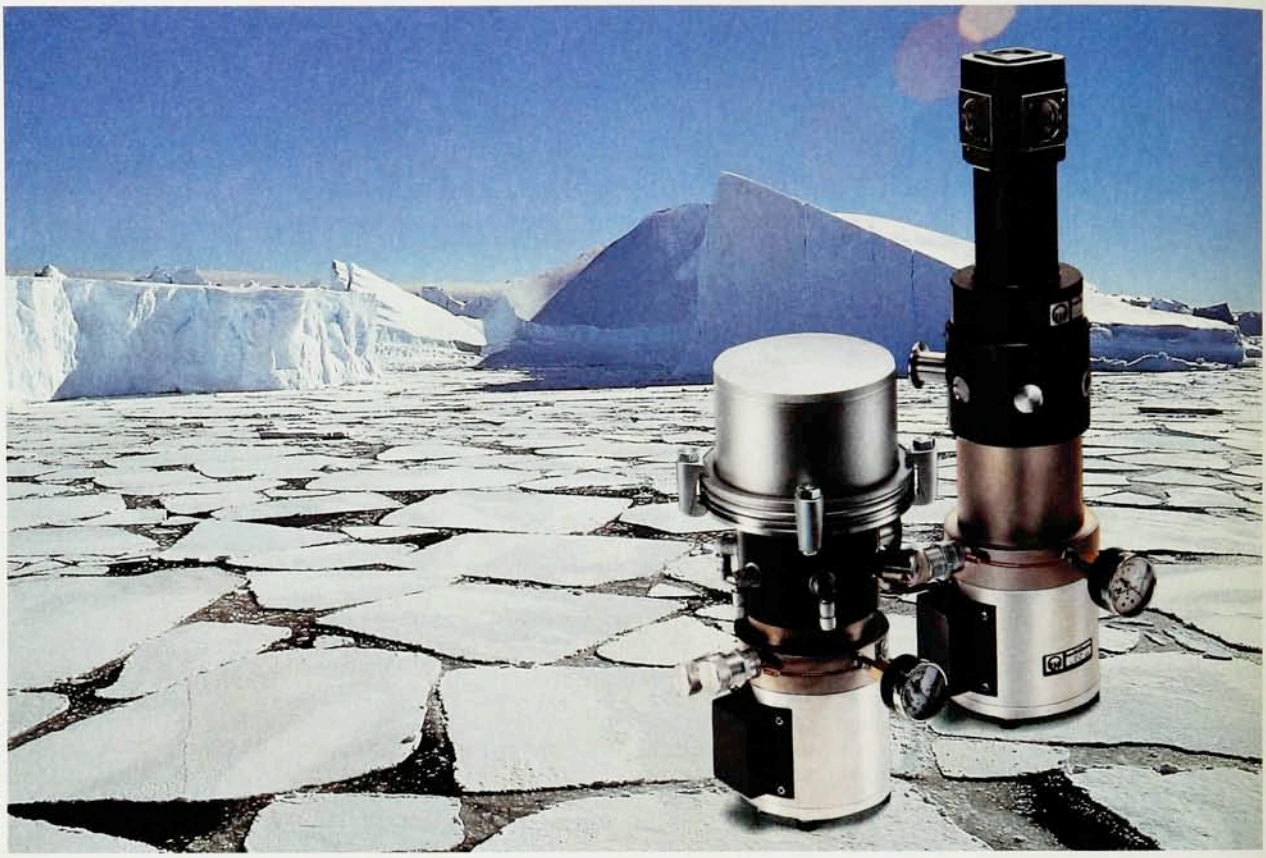
▷ *Astrophysics*

17. Experimental verification of the general theory of relativity.
18. Gravitational waves.
19. Cosmological problem; the con-

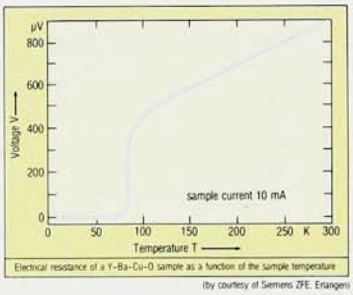
Vitaly L. Ginzburg is in the theoretical department at the P. N. Lebedev Physical Institute of the USSR Academy of Sciences, in Moscow. He has worked on condensed matter, astrophysics and other theoretical topics.

COOLING HIGH T_C SUPERCONDUCTORS 10 – 300 K

CD-Bonn



182.9 61 11.038.02



Electrical resistance of a Y-Ba-Cu-O sample as a function of the sample temperature
(by courtesy of Siemens ZFE, Erlangen)

The LEYBOLD refrigerator-cooled cryostats are ideally suited to cool down High T_c Superconductors over a wide temperature range without liquid coolants. The dual stage Basic Unit with the extension set ROK for optical or RNK for magnetic experiments is a closed cycle system that is capable of producing temperatures of 10-300 K. The single stage RSK 30-300 unit achieves temperatures of 30-300 K.

Features: • Benchtop accessibility • Fast sample exchange and multiple sample mounting capability • Electrical controller provides selective temperature adjustments • Optional computer-controlled temperature setting.

Interested? Call: 1-800-433-4021

LEYBOLD VACUUM PRODUCTS INC.

5700 Mellon Road, Export, PA 15632

Worldwide: LEYBOLD AG, Bonner Strasse 498, D-5000 Cologne 51

LEYBOLD

Innovative Vacuum Technology

A Degussa Company

Circle number 8 on Reader Service Card

nection between cosmology and high-energy physics.
20. Neutron stars and pulsars.
21. Black holes.
22. Quasars and galactic nuclei; formation of galaxies; hidden mass (dark matter) and its detection.
23. The origin of cosmic rays and cosmic x-ray and gamma-ray emission; gamma-ray astronomy at superhigh energies.
24. Neutrino astronomy.

In general, the topics speak for themselves. Only item 4 needs to be clarified. The question of metallic exciton (electron–hole) liquids remains from the previous editions of the list. The problems in solid-state physics that are more urgent now (the metal–dielectric transition, charge- and spin-density waves, disordered semiconductors, spin glasses, the quantum Hall effect, mesoscopics and some other problems) are only mentioned in my new book. The point is that there is so much material in this category that I decided to "leave it overboard," in the sense that I did not make even short comments, as I did in the other cases.

In the course of time the contents of the list will change: Some subjects will be discarded and others added. For instance, the problem of high-temperature superconductivity was on my list as far back as 1971, when high-temperature superconductors had not yet been created. But the question remains very urgent, although in anticipation of the future we could also mention room-temperature superconductivity. The new edition of course includes that problem, but I have not changed the wording of item 2. I have, however, added superdiamagnetism, that is, the problem of substances that are not superconductors but possess a very high diamagnetic susceptibility.

I think every physicist ought to know something about all the problems mentioned in the list. If the goal is only general information—without formulas—I believe it will be easy to achieve.

I would like to know what my colleagues think of both the general ideas I have discussed here and, more concretely, my proposed list. I hope they will write to PHYSICS TODAY with their opinions. The resulting discussion should be interesting for many physicists.

References

1. V. L. Ginzburg, Sov. Phys. Usp. **14**, 21 (1971).
2. V. L. Ginzburg, *Physics and Astrophysics: A Selection of Key Problems*, Pergamon, Elmsford, N. Y. (1985). ■