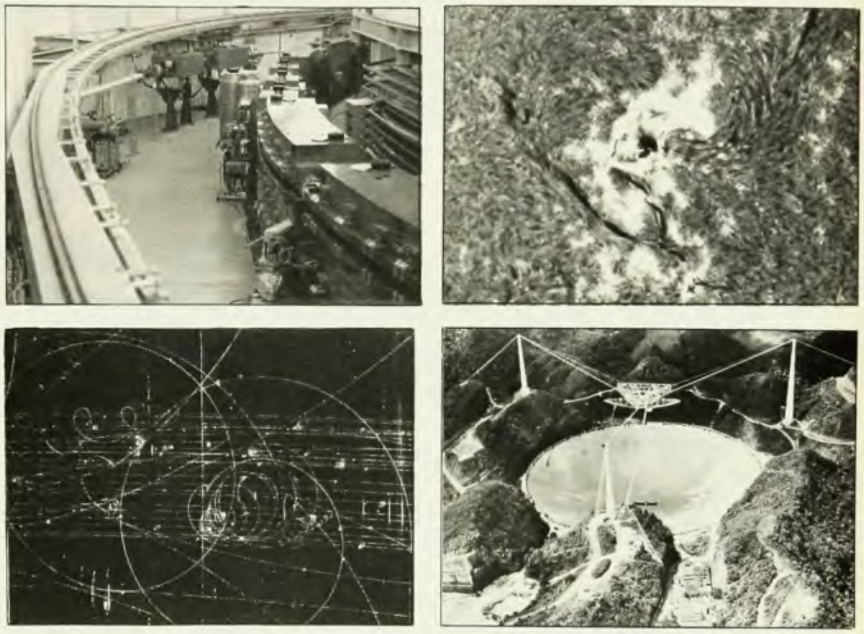
Soviet theorist names the hot topics

Key Problems of Physics and Astrophysics

V. L. Ginzburg
148 pp. Mir, Moscow (US distributor: Imported Publications, 320 W. Ohio St., Chicago), 1976. $2.25 clothbound

Reviewed by Jesse L. Greenstein



Scenes from modern physics and astrophysics. Clockwise from upper left are the DORIS accelerator ring (DESY-Hamburg, W. Germany), a solar flare (NOAA), the radiotelescope dish at Arecibo (Cornell University) and a bubble-chamber photo of decaying particles (Brookhaven Nat'l Lab).

This unusual book is a rare personal exploration of a wide range of current physics and astrophysics by a distinguished scientist; it was planned to educate budding scientists on important new topics. Vitaly L. Ginzburg makes difficult questions appear simple and repeatedly argues what is most important, "hot," with an almost moral fervor. I wish I could have written such a book—and that other leading generalists would.

Ginzburg is a brilliant physicist–astrophysicist at the Lebedev Physical Institute in Moscow. He has written several books on cosmic-ray and plasma physics and on high-energy phenomena in and radiation strength from astronomical objects. He has dealt with the important controversy as to whether radical "new physics" is required to explain the enormous energy output and rapid variations of the quasars. In general he has taken (properly, in my opinion) a somewhat conservative position on whether the redshift of the galaxies and quasars is a universal cosmological phenomenon, or arises from some as yet unknown physical principle.

The book is an expansion of a 1971 article that was to introduce a series of lectures at the Moscow Institute of Physics and Technology. The series was designed to reduce the barriers of student and budding-scientist overspecialization by covering material outside normal courses and discussing current research and "what problems . . . appear now especially important and interesting." The book is excellent reading for intelligent undergraduates and for graduates facing a decision on the field in which they will work. It should prove an education for specialized research scientists, teachers and Federal-agency decision-makers and planners. It is unusual for an individual to publish his decisions on what is "hot"—but his actions must be based on such decisions. Personally, I would prefer Ginzburg's choices to those of some planning committees and governing bodies. But he faces seriously, and with no easy solutions, the difficulty in planning financial support of science, given the unexpected nature of discovery and the impact of new technologies.

Ginzburg's reading is omnivorous and a model of internationalism: This small book (10 × 14 cm page size) has 119 references reaching into 1974 (at least 250 papers), from English- and Russian-language sources equally. He spends a few pages on each topic and the philosophical and practical questions and applications. Covered are controlled thermonuclear fusion (magnetically confined and laser-induced), high-temperature superconductivity, liquid crystals and the possibility that metallic hydrogen (or other unusual solids) may contribute to efficient large magnets for controlling plasma. X-ray, gamma-ray and superpower lasers are subjected to order-of-magnitude considerations. Ginzburg gives particle physics both little space and little future; perhaps the results of the last two years would have altered his negative stance. He discusses CPT invariance, interactions and cross sections at super-high energy and the mass spectrum. He describes the shifting boundary between particle and moderate-energy physics and the growing remoteness of "microphysics" from the stuff of ordinary matter. The book predates charm and so leaves quarks as mainly curiosa. He deplores the not-so-glorious battle for funds for larger accelerators, based—he believes—on an overestimation of their prompt and wide scientific applications.

In astrophysics he concentrates on rapidly changing vistas in general relativity and high-energy astrophysics. Gravitational waves probably will, in the long run, be a most fascinating confirmation of general relativity. The violently variable radiation of quasars and Seyfert nuclei, the x rays from possible black holes in massive stellar binary systems (and more recently from globular clusters), supernova outbursts and remnants (x-ray sources) demonstrate the effect of energetic plasma and deep gravitational-potential wells. X-ray and gamma-ray astronomy are space-age astronomy at its best, providing a revolution in perspective in an important field. The high-energy electrons found by radio telescopes in radio galaxies and quasars reach their extreme in pulsar magnetospheres.

Ginzburg is a generalist whose encyclopedic reading and depth permit coverage of a variety of such novel, specialized material. He uses order-of-magnitude (nearly dimensional) formulas, sufficient to provide quantitative estimates. He appreciates the experimenter's contribution. The book provides a model of how non-theorists can judge what realms of theory may be illuminated by work in a new range of photon and particle energy, how new technologies may be used to good effect.

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Light Scattering by Phonon–Polaritons

R. Claus, L. Merten, J. Brandmuller
237 pp. Springer-Verlag, New York, 1975. $29.70

For those of us who are neither too young nor too old (and who have been paying attention), polaritons have been a lively microlaboratory in which to learn physics, sharpen perceptions and gain sophistication. From the work of Kerson Huang, John J. Hopfield, and Ugo Fano in the 1950's we learned how the coupling of electromagnetic vibrations to crystalline excitations (either phonons or excitons) affects both the optical properties of the crystals and the behavior of the fundamental excitations themselves (the longitudinal–transverse frequency splitting, for example).

The coined term "polariton" stands for a wave of electric polarization shared between the electromagnetic field and the crystalline degrees of freedom. Although Huang demonstrated dispersion curves for phonon–polaritons in 1951, the existence of polaritons remained figmentary until they were observed directly as elementary excitations in their own right, in inelastic light-scattering spectroscopy, by Charles H. Henry and Hopfield in 1965. Thereafter the perception of polaritons' reality grew and their popularity spread to all corners of the earth, carried partly by the floodtide of laser-light-scattering spectroscopy and partly by the wonder of it all.

That the volume under review is entitled *Light Scattering by Phonon–Polaritons* is due to the fact that there is no other comparable way to study phonon–polaritons. Although some properties of polaritons are known from such indirect techniques as infrared reflectivity, to study them *in vivo*, as it were, one simply must penetrate the crystal as with light. Practitioners of the light-scattering art mapped out many beautiful polariton dispersion curves, and we came to regard these as *being* polaritons.

The study of these entities has helped us to understand other phenomena. Ferroelectricity, for example, is often associated with a "soft mode" exhibiting remarkable temperature sensitivity; its polariton does interesting tricks. Anharmonic phonon interactions have been fruitfully studied. Such marvels as frequency-dependent phonon damping and Fano interferences have been demonstrated with startling clarity and directness.

Polariton damping, however, brings a sticky end to the subject. When we contemplate the damping of such a composite excitation, we must keep clearly in sight the separate parts of which it is made, as well as the specific ways its parts are probed in an experiment. Representing the excitation as a point in complex frequency–wavevector space is inadequate and, in fact, thinking of it as a polariton no longer helps. I would therefore wish to augment my study of the living polaritons in this book by reading about dying polaritons in the response-function approach of A. S. Barker Jr and R. Loudon.

With this exception, I believe that the authors have given an excellent and complete account of the behavior of polaritons. They have included plenty of diagrams and formulas to make the ideas precise, but they have not neglected the philosophy that brings the ideas to life.

The book will be useful to students and practitioners of solid-state physics whose interests run to lattice dynamics and phonons, to light scattering or to electromagnetic propagation. Many of the ideas are, of course, generalizable to electromagnetic energy coupled to other excitations than phonons, so those interested in such diverse topics as plasmons and surface waves may also hope to find inspiration here.

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Detection and Spectrometry of Faint Light

J. Meaburn
270 pp. D. Reidel, Boston, 1976. $34.00

For the past 15 years John Meaburn has been designing spectrometers to analyze the visible and infrared emission from gaseous nebulae. In this fifty-sixth volume of the Astrophysics and Space Science Library he has set down a method for evaluating general types of spectrometers. His aim, as stated in the preface, is to "bridge the gap between the pure instrumental physicist and the user of detectors and spectrometers."

The monograph is organized into three general parts: introductory chapters on spectrometry, detectors, prism spectrometers and gratings; intermediate chapters describing various spectrometers, and a final chapter on signal-to-noise ratios as the principal criteria of merit. The introductory chapters are brief, tending more to definition of terms than explanation of principles. The intermediate chapters consist of an instrument-by-instrument analysis of the parameters needed to determine a potential factor of merit $Z_{\rm pot}$ for each spectrometer. The final chapter attempts to relate some of these parameters to the signal-to-noise ratio of a system.

The book is a rather complete catalog of individual instruments and combinations of instruments. Faced with the problem of choosing which instrument—a grating monochromator, a Michelson interferometer or a PEPSIOS or SISAM monochromator—to use in a particular experiment, one is likely to throw up his or her hands and use whatever is handy. With the method illustrated in the text, a rapid paper-and-pencil analysis of the $Z_{\rm pot}$ for the several spectrometer systems might be made without too much difficulty.

Despite the author's attempt in his final chapter to relate the parameters so carefully listed in the earlier chapters to the signal-to-noise ratios, much of the effort is abandoned in favor of an analysis that could have been carried forward without most of the material in the preceding chapters. Granted, as the author asserts, that factors listed in the intermediate chapters are related to the signal-to-noise ratios "in a very complex and often variable way," there is no indication of what importance the author puts on $Z_{\rm pot}$ relative to these ratios as calculated in the three illustrative problems in the final chapter.

Meaburn makes a modest attempt to explain the workings of the various instruments, but the sheer number of devices considered and the use of figures from original papers do not allow a pedagogical approach. One cannot understand many of the fine points unless one has read some of the basic references to spectrometers given in the text. The book needed the hand of a good copy editor—a lack of commas makes the text frustrating to read. Most readers, however, will use this as a reference, dipping in where needed and ignoring the rest.

The detection of faint light, mentioned in the title and covered in Chapter 2, is a brief review of most commonly used visible-light detectors and a description of