deflection electronics, the thermal capacity of the deflection coil, and the saturation flux of the ferrite pole-pieces. It is difficult at present to see how multiple lenses could be used similarly in conjunction with a deflection system to cancel off-axis aberrations, but to my knowledge, this has never been investigated. Presumably, deflection would have to be electrostatic because a field of tens of kilogauss would be needed to deflect keV argon ions, and it would not be possible to modulate such a field with adequate bandwidth.

A possible way to avoid the large-field deflection problem altogether would be to only deflect the beam over a small distance in one direction and move the sample mechanically to provide the other scan direction as is done in the EBES electron-beam system.

In some ways, the deflection and focusing problem for ions is similar to—and perhaps no more serious than—that which confronted workers and electron beam lithography in the early 1960's, but it nonetheless appears formidable at the present time.

The point raised on the definition of resist sensitivity has arisen frequently. I tend to support the contention that a definition of charge per unit area is more useful in this technological science than the more academically correct definition of charge per unit volume. In general, one is interested in the efficiency with which a given radiation can expose thin layers of resist, which in practice are of similar thickness. As pointed out, ions are more efficient because their energy is more completely dissipated in the resist rather than in the substrate, as it is with electrons.

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Grantsmanship in advertising

In the December issue, as in previous issues, advertisements (pages 92–106) have appeared for senior faculty with the words "Proven ability to generate grant support is a requirement," while nothing is said about teaching experience or competence other than that "most" faculty "take a strong interest" in teaching programs.

Such advertisements in effect set new standards for faculty procurement and are ultimately influential in determining qualifications and obligations of faculty and the quality of academic teaching and research. Surely such advertisements warrant discussion before they create new professional norms.

A number of issues are involved. First, and perhaps foremost, is the obvious down-grading of teaching. Indeed, such an advertisement closes the door at once to anyone who is primarily concerned with teaching.

It also closes the door to anyone whose research requires little or no grant support. Conversely, it tends to put a premium on research that is costly and requires, or has obtained, large grant support in the past. This is likely to mean that the research involved is in a fashionable field and of stereotyped character long supported by federal agencies. It is in effect an announcement that anyone interested in an unconventional field, or in launching something unconventional, or in changing fields need not apply. In short, it tends to bar the innovative, the unconventional in favor of the familiar, the sure-fire, in the name of research!

Is it too much to infer that an advertisement for grant-bringing faculty such as we are discussing is really interested neither in teaching nor in truly original research, but primarily in the grant funds themselves!

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More on atomic resonances

The interesting article on atomic resonances by Manfred Biondi, Arvid Herzenberg and Chris Kuyatt (October, page 44) kindly credits me with a remark that is actually due to the late Robert L. Platzman, and with other incidents I don't recall. I'd like to draw attention to Platzman's seminal influence on the extraordinary outpouring of physics that followed George Schulz's discovery of the 19-eV helium resonance and to add some other footnotes to the article's description of those events.

Franck and Grotrian's paper, to which Platzman drew my attention, identified the critical factor controlling the electron affinity of atoms and molecules, namely, the occurrence of unfilled electron shells in their structure. This assessment of the affinity phenomenon has held true for 60 years. This paper also remarked, offhandedly but very farsightedly, that any electronic excitation provides unfilled shells and thereby the opportunity for electron attachment; hence follow the "Feshbach resonances" in atoms and molecules.

James Franck transmitted to Platzman his drive toward providing broad outlines and interpretations of the electric, magnetic and spectral behavior of physicochemical systems. Thus Platzman stressed in the 1950's our ignorance of the spectral distributions of oscillator strength, that is, of the dielectric properties of matter over 2–3 decades of the spectrum in the far ultraviolet and soft x-ray ranges. He also anticipated that synchrotron light sources would serve to fill this gap. Efforts to stimulate work in

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this area led eventually to L. M. Branscomb's recruiting of R. P. Madden's team to tap and instrument the NBS synchrotron with the goal of extending absorption spectroscopy and radiometry in the uncharted range. This source became operational a few weeks after the publication of Schulz's discovery, as noted in PHYSICS TODAY.

It was Platzman, again, who drew my attention to Lassettre's observation of a striking 60-eV energy loss of electrons in helium and who encouraged my brushing up of much older work to describe its profile. The simultaneous onset at NBS of the synchrotron optical facility and of J. Arol Simpson's electron spectrometer, with ready access to many target samples, led then to wholesale discoveries of resonances throughout the excitation range of 10–100 eV, often on a "while you wait" basis. (M. Inokuti recalls how V. Cermak—recently and untimely deceased—mentioned to Platzman a presumable excitation level of N_2 near 12 eV, during a visit at Argonne; Platzman rang up Simpson at NBS right away and the discovery of the new level was reported back by evening.) These developments gave me the chance of spending a couple of years just helping to identify new resonances.

The resonant excitations of atoms and molecules generally involve tight correlations between electrons and also with nuclear motions. Their ubiquitous occurrence and easy observation have provided the first broad overview of these correlations. Curiously, this view unfolded distinctly from phenomena at rather high excitation energies, of 20–50 eV, even though correlations presumably play their main role in chemical transformations at thermal energies.

A final, and more personal, remark: Biondi's observation of the resemblance of Schulz's resonance profiles to a dispersion curve (page 46) coincides with my own reaction to Beutler's resonant spectrum in 1935. This observation was in fact my only contribution to the interpretation of this spectrum, as its analytical implementation was actually provided by Fermi.

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High-school teaching

In reference to Robert Feldman's guest comment concerning a former college teacher at the high-school level (January, page 9), my own teaching experience in high school (I am the only PhD in the school district and the only physics instructor) concurs with most of his observations. I would hope that high-school teaching would continue to be suggested as a realistic optional career for physicists wanting to remain in academia.

I have found such a position both rewarding and challenging, offering opportunities beyond those implied by Feldman. Though research in physics at high schools is basically impractical, the computer provides high schools an unprecedented research tool with which badly needed local research into educational problems can be conducted by research-oriented staff members. Above-average high-school students can serve as researchers, much as do graduate students in universities, and thereby gain unique problem-solving skills toward improving their own school. Three such students have already joined me in presenting papers at two State-wide professional teachers' conventions this school year. These students, another staff member and I essentially form a research group, which has brought about positive, data-based change in our school.

Though such unique research opportunities are functions of the insight of local school administrators and officials, as well as of available computer facilities, I think their existence may indicate the potentially growing attraction of physicists toward high-school teaching. I would also hope that a greater range of academic freedom than that stated by Feldman is practiced. My experience has shown me that in principle the difference in educational philosophy between high schools and institutions of higher learning can be minimal.

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What is basic research?

People err when they attempt to define basic research. Our understanding of it is evolving and, therefore, incomplete. Rather than attempt a definition, we have simply listed those characteristics of basic research (and basic research scientists) that touch on the essence of the concept, or at least help us to recognize it when we see it.

Objective aspects

▶ Basic research is an attempt to understand how the universe works. It is a search for order and purpose in the universe. It involves the forming of a unified view of reality.

▶ Basic research works with immutable laws so that its value persists and there is an accumulation of integrated information.

▶ Basic research involves understanding cause and effect relationships.

▶ It is periodically examining its fundamental assumptions and foundations.

▶ It provides critical tests of existing theories and models.

▶ It involves new inter-relationships among old concepts as well as the introduction of new concepts.

▶ Basic research involves a classification or cataloging of all possibilities.

▶ It is the observation, recording, and systemization of information on natural phenomenon.

Managerial and societal aspects

▶ Because basic research discovers the underlying laws it is multi-impact in its scope. Basic research in one area is often applicable in another area.

▶ It attempts to provide a complete catalogue of options.

▶ The continuous development of fundamental knowledge is absolutely essential for sustaining applied research.

▶ Sometimes good basic research arises from considering a practical problem, sometimes it does not.

▶ Basic research cannot be programmed. Specifically, the idea has to come from the recipient not the granter of funds.

▶ If α_{ij} represents the probability of a researcher in area i discovering something significant in area j, then α_{ij} $(i \neq j)$ is a significant number. Many organizational structures supress α_{ii} type research.

▶ Many times a breakthrough comes in an entirely unexpected way.

▶ The freedom to pursue leads (unencumbered by the organizational element in which the scientist is embedded) lies at the very core of the research process.

▶ Many times cross-fertilization is productive of basic research.

▶ Some research institutions (as well as individuals) seem to have been a nucleus for good research.

▶ One needs many acorns to grow just a few oak trees. In the same way, one needs a large sample size in order for the truly outstanding contributions to be made by the relatively few. In general, one needs a large level of effort in basic research. There may be a critical mass effect.

▶ Some basic research efforts require group effort. Others are hindered by group effort.

▶ The time constants for doing research are long. It takes a long time to build up a respectable research effort (but a short time to destroy one).

▶ In some areas of basic research the US is not the leader. In some areas the US has lost its lead.

▶ The tragedy of the commons is now operative with regards to basic research in industry in the US.

Psychological and personal aspects

▶ Some people are incapable of it. One must pick the proper person for basic research.

▶ A good research worker is willing to tackle the significant problem as opposed to the pot-boiler type. He is willing to risk criticism to attain the goal of a significant gain.

▶ Creative research requires confidence in oneself.