V. D. Fil'. *Electronic mechanism of acoustic-pulse transfer in magnetic fields.* Experimental[1,2] and theoretical[3,4] studies of the propagation behavior of sound pulses in pure metals at low temperatures have shown that in dissipating the energy of the sound wave, the electron subsystem returns it to the lattice in forms other than incoherent phonons alone. An additional relaxation channel involving radiation of a coherent sound wave by the electrons is possible under certain conditions. If we are dealing with a sound pulse, i.e., a wave packet that is bounded in time and space, we find that because of the large difference between the electron and sound velocities v_F and S the acoustic field can be detected where it cannot be according to the laws of ordinary acoustics. This phenomenon, which is known as electron transport of sound, is conceptually similar to effects of anomalous penetration of an electromagnetic field into a metal (AFP), but the acoustic transparency of the metal and the resulting determinacy of the sound wave vector **q** in the metal endow it with a number of specific features.

Electron transport of a sound pulse is observed best in the propagation of a sound wave perpendicular to a weak magnetic field H.[1] In this case, the electron-density perturbation determined by the deformation field of the wave is transferred in space at velocity v_F through a distance equal to twice the Larmor radius R into the part of the specimen not occupied by the main pulse, where it gives rise to an acoustic "precursor." The delay time of the "precursor" is linear in H^{-1}, but the slope of the line is proportional to the extreme-value Fermi momentum. This last circumstance makes it possible to measure the dimensions of large Fermi-surface cross sections with high accuracy ($\sim 1/qR$). An estimate[3] indicates that the amplitude of the "precursor" is proportional to the square of the deformation potential at the effective-interaction point; thus it becomes possible to measure the anisotropy of this important electron-phonon interaction parameter.

By analogy with AFP studies, this should be called a path mechanism. This size of the "precursor" in path transfer is no more than a few percent of the main-signal amplitude, since selection of the electrons that participate in formation of the transport sound pulse is governed solely by the geometry of the Fermi surface.

However, if we single out a certain group of electrons with the aid of resonant interaction with the input acoustic field, a substantial increase in the amplitude of the transport signal should be expected on the basis of reciprocity considerations. This phenomenon has been demonstrated in Ga[2] by observation of Doppler-shifted cyclotron resonance on open orbits.[5] Since the open direction in coordinate space coincided with the sound propagation direction, the acoustic field was observed to be transferred at the Fermi velocity along **q** for the entire length of the specimen; given exact tuning to resonance, the amplitude of the transferred signal was comparable to that of the main signal. The effect has also been observed independently in Cu and Ag.[6]

The collisionless-absorption edge that can be observed when a strong field H deviates from exact perpendicularity to **q** by an angle $\varphi_0 \sim s/v_F$ can also serve as an effective selection mechanism; this usually known as the "slant effect."[7] In this case, the coherent sound field carried along H is also comparable to the main signal.[2]

In the examples given above, the magnetic field "included" some mechanism for selection of electrons capable of transporting a coherent acoustic signal. The sole selection mechanism in a zero field is found to be "Landau damping"—only electrons moving in phase with the wave, i.e., at an angle φ_0 to the plane normal to **q**, contribute to absorption of the sound. These electrons also transport the acoustic field out of the spatially limited beam, diffusing it transversely over the free-path length of the carriers. A characteristic peculiarity of this transport is that it is suppressed by a weak magnetic field (~1–2 Oe) as a result of curving of the electron paths.

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E. L. Feĭnberg. *Hadron clusters and semibare particles in quantum field theory.* Experimental data on the multiple generation of hadrons at high energies point increasingly to a significant role of the cluster (or fireball) mechanism proposed long ago, according to which unstable, rather heavy hadronic formations (with masses of 2–5 GeV) form initially and then decay independently into final stable hadrons.[1] It is still not clear whether they are simply as yet unidentified resonances heavier than any known ones or nonresonant fireballs. The paper stresses that the assumption that the cluster mass spectrum has purely resonant structure is equivalent to a very special hypothesis as to the structure of the polarization operator or the propagator of the hadron field. Moreover, experience from quantum electrodynamics, in which all of the necessary estimates can be made with sufficient rigor, indicates that the particle propagator naturally contains a nonresonant part.

In the bremsstrahlung of a very-high-energy electron, therefore, the electron is "semibare" after scattering: it has been deprived to a greater or lesser degree of the outer parts of its intrinsic electromagnetic field, which is restored only after a regeneration time, which may even be "macroscopically" large at very high (but quite realistic) energies, so that this semibare electron is a real, physically observable object.[2] The restoration of its structure occurs in a curious way, by decay into a normally "clothed" electron and photons. Here the mass spectrum of the semibare electron is smooth and nonresonant, with the addition of resonance peaks corresponding to the possible presence of positronium in the final state (and of threshold singularities). This object is simply an electron far outside of the mass surface (movement out in the time-like direction). This effect is the basis of the long-known effect of the large formation zone in processes of electromagnetic radiation at high energies. The conception of the formation zone had already appeared in the physics of ordinary energies. The effect of its increase with energy was rediscovered by M. L. Ter-Mikaelyan in a more general form in the case of bremsstrahlung in a crystal with allowance for recoil, etc., and was then used to study many phenomena in electrodynamics.

This effect—prolongation of the regeneration time—does not depend on the electron-field coupling constant and is of purely kinematic nature (the time necessary for propagation of the signal within the "spoiled" structure of the particle for "healing").[2] Therefore the result can be extended to meson-baryon theory or another quantum field theory. Here also, the "healing" of the particle after the interaction is accordingly relativistically prolonged. This has been confirmed in the observed relative "passivity" of the hadron system that arises on diffractive dissociation in the nucleus on its subsequent path in the same nucleus. It also holds that "healing" of the spoiled structure occurs by decay into stable hadrons and, if there are many of them, may have the quasiclassical nature of a progressive expansion (for example, thermodynamic behavior). This process can be traced in models (for example, the parton model), and the general relations for the hadron propagator enable us once again to conclude that the mass spectrum of the nonequilibrium hadron formations consists not only of resonances (of which there are, however, many more than there are in electrodynamics), but also of the nonresonant part. It may be represented by clusters.

The subsequent interactions of these clusters differ from those of the semibare electron primarily because the electron, even though it is deprived of the outer regions of its electromagnetic field, has the usual change in scattering on other particles, i.e., is scattered at the same intensity. In contrast, the hadron, which interacts with all parts of its shell, having been "truncated" (parton model, etc.), must interact with a smaller than normal cross section. Another peculiarity (and one that we have essentially already covered) is that, because of the small interaction constant, even a heavy semibare electron recovers its structure almost exclusively by decaying into a clothed electron and one photon, while many orders of perturbation theory are equally important in hadron physics. Therefore a sufficiently heavy cluster decays into many particles.

All of this conforms rather well to a conception advanced long ago in cosmic-ray physics: that of fireballs that have small interaction cross sections prior to decay,[5] and to the hypothesis that the nucleon is derived of a peripheral pion in ordinary collisions and therefore also becomes passive for a certain time.

Thus, the comparison with experience from electrodynamics indicates convincingly that there is a natural place for nonresonant clusters in quantum field theory.

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Translated by R. W. Bowers
Edited by D. L. Book