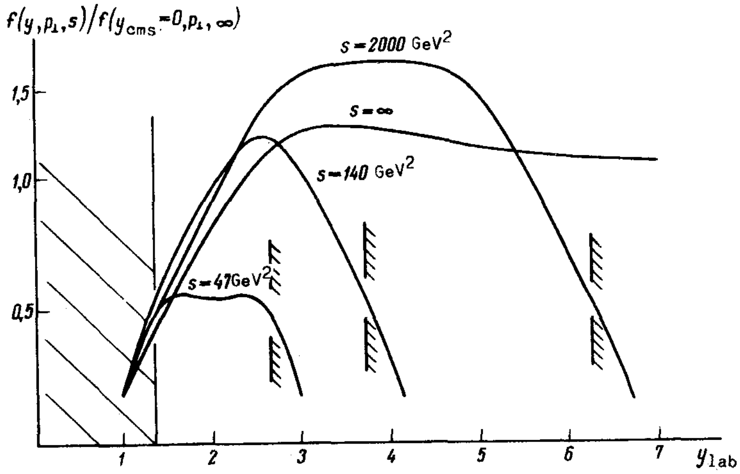


Fig. 3. Distribution of pions produced in the reaction $pp \to \pi^- X$ with respect to the longitudinal velocities ($p_\perp$ = 0.4 GeV). The solid curves were calculated from (7). The shaded region on the left is the region of fragmentation (three-reggeon limit), where formula (7) no longer holds, since $\beta_2$ is large.

The fraction of pions produced via resonances ( = 2/3) and the average transverse resonance ass ($m_{\perp\rho}$ = 1 GeV) were also taken from [9].

We note finally an interesting qualitative effect observed by the Saclay-Strasbourg group [3]. With increasing $p_\perp$ (at $p_\perp$ > 500 MeV ≥ $\langle p_\perp \rangle$), the inclusive cross section begins to grow faster with increasing energy, owing to the increase of $\alpha_c$ and $\beta_c$ in (7) with increasing $m_{\perp c} = [m_c^2 + p_{\perp c}^2]^{1/2}$.

We recall in conclusion that formula (7) does not claim to describe the experimental data exactly. We only wished to show that phase-space effects come into play even at sufficiently large s and can explain the role of the inclusive cross section in the pionization region. A detailed discussion of the energy dependence of $f(p_c, s)$ in a model of this type, with allowance for the decay of the resonances, will be published in the journal Yadernaya Fizika.

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## POSSIBLE METHODS OF PLASTICITY CHANGE IN A SUPERCONDUCTING TRANSITION

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Dynamic mechanisms of weakening in N-S transitions, due to the decrease of electron dragging of dislocations, and quasi-static mechanisms due to the inhomogeneity of the dislocation structure, are discussed.

The transition of a superconductor from the normal (N) state to the superconducting (S) state at a temperature T below the critical temperature is accompanied by a jumplike increase of its plasticity (weakening [1 - 3]. This effect is observed under different deformation conditions, but always only during the stage of developed plastic deformation, and its connection with the presence of mobile dislocations in the crystal is subject to no doubt. It is therefore natural for explanations of the weakening to be based on a decrease of the electron dragging of the moving dislocations in the N-S transition. Indeed, the magnitude of the electron drag determines directly the dislocation velocity V when it moves above the barrier [4]. In addition, V can depend on the viscous drag constant B also in the case when the dislocation mobility is determined by the fluctuational surmounting of the local barriers [5]. (The first analysis of this dependence as applied to the weakening effect was first presented in [6]).

The first case can be realized when the average distance L between dislocation pinning points exceeds $L_{cr} \simeq W/\sigma b^2$, where W is the binding energy of the dislocation with the defect that pins it, σ is the specified stress, and $\vec{b}$ is the Burgers vector. The condition for the realization of the second case is the inequality $L_0 < L < L_{cr}$, where $L_0 \simeq cm/B$ is the critical length that determines the strong-damping condition, $m \sim \rho b^2$ is the mass per unit dislocation length, ρ is the density of the material, and c is the speed of sound.

In both cases, the ratio of the dislocation velocities in the N and S states is inversely proportional to the constants of the viscous electron dragging:

$$V_N/V_S = B_S/B_N. \qquad (1)$$

Relation (1) agrees well with the results of many experimental papers (see, e.g., [7]). There are, however, data that cannot be explained on the basis of (1) alone. In particular, under conditions of steady-state creep the ratio of the rates of plastic deformation in the S and N states exceeds the ratio $B_N/N_S$ by more than one order of magnitude.

Since the question of the mechanism whereby the plasticity is increased in N-S transitions is debatable, we deem it advisable to point out certain customarily ignored dynamic effects (which are connected with the change in the dynamic dragging of the dislocations), which cannot be reduced to (1), and to indicate the possible existence of quasistatic effects.

## 1. Dynamic Effects that do not Reduce to Viscosity.

From the diffusion theory of surmounting the barrier [9] (see also [6]) it follows that the dependence of V on B disappears when L becomes smaller than $L_0$. By increasing the density of the dislocation pinning points (say by doping) it is possible to eliminate the weakening effect [10]. It is of interest, however, to note that it also follows from the same theory [9] that the function V(B) becomes linear at an extremely low damping level, corresponding to $L \ll c(m/B)(T/Q)$, where Q is the activation energy. This phenomenon reverses the sign of the effect and can lead to strengthening in N-S transformation, but may be masked by other processes that lead to weakening.

In particular, at a low damping level, the so called inertial effect is possible, whereby the inertia of the dislocation rushing towards the barrier causes an additional bending of the dislocation segment and produces an additional force acting on the pinning points [11 - 13], leading to an effective lowering of the potential barrier; this lowering is different in the N and S states. The inertial model gives for the stress jump $\Delta\sigma = \sigma_N - \sigma_S$ a temperature dependence that agrees satisfactorily with the experimental one (see [14]). It is important to emphasize that the inertial mechanism can come into play only at stresses close to the activationless detachment stress, when the characteristic relaxation time m/B constitutes an appreciable fraction of the time of the fluctuational surmounting of the barrier.

## 2. Quasistatic Effects.

The quasistatic mechanisms, unlike the dynamic ones, are based on allowance for the inhomogeneity of the electron structure of the superconconductor, due to the inhomogeneity of the dislocation structure produced as a result of heterogeneous plastic deformation (slip bands, block boundaries, etc.). The internal stresses arising upon plastic deformation cause local changes in the width of the energy gap, similar to those produced in elast ic loading of superconductors [15, 16]. The direct influence of the dislocation on the phonon spectrum of the crystal also leads to local changes of the gap as a result of inhomogeneity of the dislocation structure of the sample. Finally, inhomogeneous distribution of the dislocations and point defects leads to changes in the electron mean free path, and this causes, in particular, local changes in the energy of the N-S boundary.

All these effects cause spatial inhomogeneity of the superconducting state and increases the density of the free energy in the S state by an amount $\delta F \sim N(0)\xi_0^2(\text{grad}\ \Delta)^2$, where N(0) is the density of states on the Fermi surface, $\xi_0$ is the coherence length, and Δ is the energy gap [17]. The presence of a gradient term in the free energy, connected with the inhomogeneity of the dislocation distribution, leads to an additional thermodynamic force that tends to homogenize the superconductor, to rarefy the dislocation clusters, etc. Conversion of this force into the effective mechanical stress $\sigma_{eff}$ acting on the dislocation yields

$$\sigma_{eff} = \delta F/\delta\varepsilon. \tag{2}$$

Here $\delta\varepsilon$ is the deformation produced when the dislocation density is equalized over the crystal. When typical superconductor parameters and data on the dislocation structure are used (see, e. g., [18]), the estimate (2) shows that the stresses $\sigma_{eff}$ can reach values on the order of $10^5$ dyn/cm$^2$. Such stresses, being small in comparison with the applied stress, are nevertheless significant under special deformation conditions (for example, when the number of mobile dislocations is depleted under creep conditions).

To assess the relative roles of the quasistatic and dynamic effects, it is highly desirable to perform experiments on samples with different dislocation structures and to analyze the change occurring in the dislocation structure as a result of the N-S transition. Great interest attaches to experiments on the mobility of individual dislocations in the N and S states, which make it possible to exclude the quasistationary effects.


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## SCATTERING OF HIGH ENERGY PROTONS BY $^{58}$Ni AND $^{208}$Pb NUCLEI


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New measurement data on the differential scattering cross sections of high-energy protons by nuclei were recently reported [1, 2]. The present article is devoted to a comparison of the theoretical calculations with the data on elastic and inelastic scattering of 1-GeV protons by $^{58}$Ni and $^{208}$ Pb nuclei, obtained at Saclay [2]. The excited states $2^+$ (1.45 MeV) in $^{58}$Ni and $3^-$ (2.62 MeV in $^{208}$Pb are interpreted as collective. The excitation of these levels is described within the framework of Glauber's theory [3] on the basis of a generalization of the method