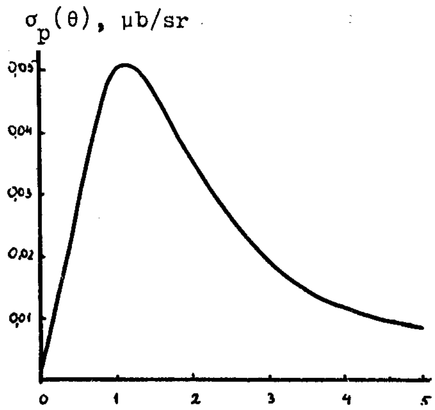
If a nucleus with zero spin is used as the target in lieu of the nucleon, then the analysis of the effect becomes simpler, since the cross section is determined in this case by only one amplitude.



It is of interest to note that the Primakoff effect should lead to a considerable enhancement of the polarization effects at small angles. Thus, the polarization of the recoil nucleons and the asymmtery of production on a polarized nucleon depend on the product of the helicity amplitudes H_4 and H_1 [5], having large contributions of the Primakoff effect, by the amplitude H_1, which is the largest of the "nuclear" amplitudes at small angles. The separation of the contribution of P to these effects makes it possible to determine the magnitude and sign of the imaginary part of H_2.

[1] R. G. Moorhouse, Phys. Rev. Lett. 16, 772 (1966).
[2] G. F. Chew, M. L. Goldberger, F. E. Low, and Y. Nambu, Phys. Rev. 106, 1345 (1957).
[3] V. M. Arutyunyan, Zh. Eksp. Teor. Fiz. 42, 1112 (1962) [Sov. Phys.-JETP 15, 768 (1962)].
[4] F. J. Gilman, Preprint SLAC-PUB-594, 1969.
[5] R. J. Walker, Phys. Rev. 182, 1729 (1969).

SECOND ORDER PHASE TRANASITIONS THAT ARE CLOSE IN TEMPERATURE

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Experiments on phase transitions in solids frequently reveal cases of several transitions that are close in temperature (for example, Rochelle salt). In the present paper we consider the phases between which close transitions take place on a unified basis, regarding them as the result of distortions of one more symmetrical phase. This "protophase" need not necessarily be observed in the experiment. The description of the dynamic anomalies, obtained by such an approach, is more complete in the sense that a smaller number of components is needed than in the corresponding description based on a separate analysis of phase transitions in Landau's theory [1]. It turns out that the phase diagram has a characteristic singularity, in that it has a point at which four different phases are in contact.

The termodynamic potential Φ will be represented here in the form of a series in terms of two quantities η and ξ, which transform in accordance with one two-dimensional irreducible representation of the symmetry group of the protophase. Thus, η and ξ are components of a two-component parameter describing transitions with a lowering of the protophase symmetry

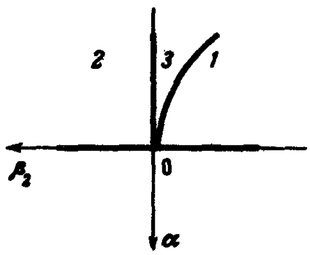
$$\Phi = \alpha(\eta^2 + \xi^2) + \beta_1(\eta^2 + \xi^2)^2 + \beta_2(\eta\xi)^2 + \delta(\eta\xi)^4. \qquad (1)$$

Unlike the usual approach [1], in expansion (1) we take into account invariants not only of the second and fourth power, but also one of the invariants of eighth power, which turns out to be significant.

The conditions for the minimum of (1) correspond to the following four solutions:

$$0.\ \eta = 0,\quad \xi = 0,\qquad 2.\ \eta = 0,\ \xi \neq 0\ \text{ or }\ \xi = 0,\ \eta \neq 0, \tag{2}$$
$$1.\ \eta = \pm\xi,\qquad 3.\ \eta \neq 0,\ \xi \neq 0.$$

The most symmetrical solution, 0, corresponds to the protophase. The most asymmetrical solution, 3, is obtained only in the presence of an the invariant with the coefficient δ in (1). Allowance for other invariants does not lead to the appearance of new solutions.



The figure shows, in coordinates α and β_2, the phase diagram for second-order phase transitions between solutions (2), i.e., the region of existence and of the stability of these solutions (phases). A diagram in terms of the pressure and temperature are similar in form.

The transition from the phase 0 to the phase 3 occurs at only one point, where all four phases touch. There is no contradiction here to the Gibbs phase rule, inasmuch as an analysis shows that no such points exists for first-order transitions, and the phases 0 and 3 either have boundaries in the form of lines, or no boundaries at all.

Besides transitions from the symmetrical phase 0 to the phases 1, 2, and 3, we can consider also transitions between the asymmetrical phases 1, 2, and 3. By way of an example, we consider Rochelle salt [2]. We shall assume that with decreasing temperature there are produced in this salt transitions between phases 1 and 3 or 3 and 2 as a result of a change in the coefficient β_2. In order for phase 3 to be pyroelectric, it is necessary to take into account in (1) the crossing term $a\eta\xi(\eta^2 - \xi^2)P$, which is equal to zero in phases 1 and 2 and differs from zero in phase 3 (P is the polarization). We add also the terms $\kappa P^2 - PE$ and minimizing (1) with respect to the variables η, ξ, and P we obtain the following results for the anomalies of the dielectric properties of Rochelle salt:

$$P = (a\beta'/2\kappa\delta)\sqrt{(T-\theta_2)(\theta_1 - T)},\quad \beta_2 = \beta'(\theta_2 - T),$$

$$\theta_1 = \theta_2 + \delta a^2/2\beta'\beta_1^2,$$

$$C_1 = C_2[1 + 2\beta'(\theta_1 - \theta_2)/\beta_1],\qquad C_2 = a^2(\theta_1 - \theta_2)/4\delta\kappa^2, \tag{3}$$

$$C_1B_1 = C_2B_2 = |dP^2/dT|_{T = \theta_1,\ \theta_2},$$

where C_1 and C_2 are the Curie constants at the upper and lower Curie points θ_1 and θ_2, respectively, and B - the coefficient in the expression $E = AP + BP^3$. The constants β', β_1, δ, α, and κ are positive.

The results in (3) are in good agreement with the experimental data [2]. To obtain a similar agreement in the usual approach [1], a larger number of constants would be necessary.

Phase transitions close in temperature are observed not only in Rochelle salt, but also in many other substances. The smaller $\theta_1 - \theta_2$, the closer is the system expected to be to the characteristic point on the phase diagram at which the four phases are in contact. It would be of interest to observe such a point experimentally, by investigating phase diagrams of substances with close transitions. An analysis of the anomalies of the physical properties in such substances can be carried on a unified basis, in analogy with the foregoing one for Rochelle salt.

[1]L.D.Landau and E. M. Lifshitz, Statisticheskaya fizika (Statistical Physics), Nauka, 1964 [Addison-Wesley, 1958]
[2]F. Jona and G. Shirane, Ferroelectric Crystals, Pergamon, 1962.
[3]A. P. Levanyuk and D.G. Sannikov, Zh. Eksp. Teor. Fiz. 55, 256 (1968) [Soviet Phys.-JETP 28, 134 (1969)].

SHOWER ENHANCEMENT OF BRANCH-POINT CONTRIBUTION AND INCREASE OF TOTAL CROSS SECTIONS AS A → ∞

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The values of the total $\pi^{\pm}N$ and $k^{-}N$ cross sections obtained [1] with the Serpukhov accelerator at 40 - 60 GeV turned out to be higher than the Regge (pole) curves or the curves of the "optical" or "eikonal" approximation [2]. The data [1] give the impression of a violation of the Pomeranchuk theorem, if it is assumed that $\sigma^{(tot)}$ takes on a constant asymptotic value $\sigma^{(tot)}$ = const already at $E \geq 20$ GeV, since here $\sigma^{(tot)}_{k^-p}$ turns out to be larger by almost 3 mb than $\sigma^{(tot)}_{k^+p}$, which is almost constant still at $E \leq 20$ GeV [3].

They can be understood, however, within the framework of the scheme of complex angular momenta [2, 4], if: (a) $\alpha'_P(0)$ and $\alpha_\omega(0)$ are shifted from the values ∿ 0.5 used earlier to the region ∿ 0.3; (b) the residue of the P pole, i.e., the value of $\sigma_\infty = \sigma^{(tot)}(E \to \infty)$ is greatly increased (by 10 - 15 mb); (c) besides the "optical" approximation diagrams b and c of Fig. 1, account is taken also of diagrams d and e, which correspond to shower production upon rescattering and greatly increase the contribution of the branch points.

All this leads to the appearance of a deep minimum [4] on the $\sigma^{(tot)} = \sigma(E)$ curves at $E \sim 40 - 60$ GeV, in place of a minimum [2] at $E \sim 10^4$ GeV in the "eikonal" model.

The most important is the first PP branch point (the branch points at the other singularities and the following P branch cuts are hardly noticeable). Taking only these into account, we obtain for the average of the π^-p and π^+p cross sections (or k^-p and k^+p, or $\bar{p}p$ and pn, or pp and pn):

$$\sigma^{(tot)} = \sigma_\infty [1 - \frac{\beta}{\xi + \xi_P} + \sum_{a \neq P, \omega} r_a e^{-(1-\alpha_a(0))\xi}], \quad (1)$$

where $\xi = \ln(E, \text{GeV})$ and $\xi_P = R_P^2/\alpha'_P(0)$ is known, since the radii R_P of the Regge P vertices are determined by the dependence of d /dt on t; for $\pi^{\pm}p$ [2] and $k^{\pm}p$ we have respectively $R_P^2 \approx 1.4$ and 1.5 $(GeV/c)^{-2}$. The parameters σ_∞, r_a, $\alpha_a(0)$ and β are chosen to suit, with $\beta = C\beta_0$, $\beta_0 = \sigma_\infty/32\pi\alpha'_P(0)$, and $\alpha'_P(0) = 0.47\ (GeV/c)^{-2} = 0.47 \times 0.39$ mb. In the "eikonal" model $\beta = \beta_0$, i.e., C = 1, and when account is taken of diagrams

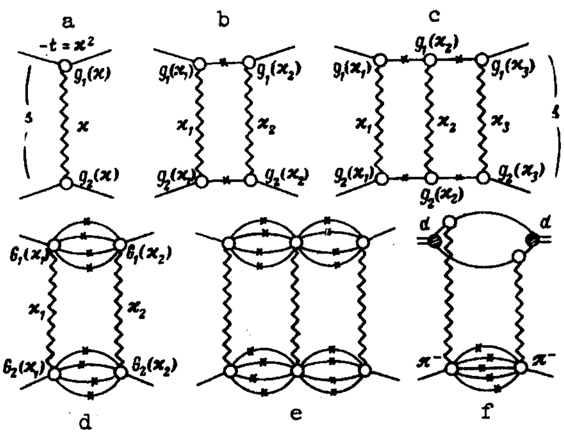

Fig. 1

1) Reported at Conference on High Energy Physics, Kiev, 22 October 1969.