tron conditions. It is not impossible that a totally new type of dischargelss plasma reactor might be designed on this basis. The contents of this study are set forth in greater detail in[1,5].

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M. S. Rabinovich and V. N. Tsytovich. New Collective Methods of Charged-Particle Acceleration. 1. Collective methods of accelerating charged particles were proposed some time ago by Veksler (see[1,2]). Attention was initially focused on theoretical developments (see[3,4]), and then on experiments with relativistic electron rings[5]. Papers on relativistic rings are well known, and note should be taken here of the progress that has been made in the acceleration of multiply charged ions. Considerable progress has been made in another direction in recent years (1968–1972): the study of linear collective acceleration of ions in powerful relativistic electron beams. More than six experimental groups (see[6]) have used relativistic electron beams with energies of 1 – 2 MeV, currents of $5 \cdot 10^4$ to 10^6 A, and powers of 10^{10} to $2 \cdot 10^{12}$ W, and they have obtained accelerated ions (accelerated in the direction of electron motion) with energies from 2 to 12 MeV/Z in numbers of 10^{12} to 10^{15} particles per pulse, which corresponds to accelerating fields from 40 to 400 mV/m and acceleration powers from 10^9 to 10^{11} W. These parameters are at the moment better than those recently obtained with relativistic electron rings, forcing, on the one hand, a review of some of the earlier theoretical developments[4] and, on the other, examination of new proposals being advanced for discussion of general physical principles that might increase the efficiency and power of the new collective accelerators using relativistic electron beams and dense plasmas. But until now neither the acceleration mechanism nor the cause of termination of the acceleration even before the end of the electron pulse has as yet been fully clarified. This is another cogent reason for developing the theory.

2. One of the basic problems of collective accelerators is that of producing strong collective electric fields. Progress in this direction is possible basically by increasing the plasma density in the relativistic beams. From the simple relation $E_{max} = 4\pi n_0 e a$, putting $a = c/\omega_{pe}$, and $\omega_{pe} = \sqrt{4\pi n_0 e^2/m_e}$, we obtain $E_{max}[\mathrm{mV/m}] = (1/10\,000)\sqrt{n_0(\mathrm{cm}^{-3})}$. For existing electron beams with $n_0 \approx 10^{13} - 10^{15}\ \mathrm{cm}^{-3}$, the fields E_{max} reach 300 – 3000 mV/m. But in a denser plasma, for example a laser plasma, they may reach 10^6 mV/m and higher.

3. Excitation of such fields requires the use of the maser-buildup principle, i.e., avalanche-like buildup of strong fields from initial weak fields. These instabilities may be of two-stream, parametric, or specific nature due in part to the charge neutralization that is necessary for equilibrium of a relativistic electron beam. It is necessary that nonlinear saturation processes not interfere with attainment of fields near E_{max}.

4. The fields excited must be quite regular in nature; this can be attained, for example, by reducing the energy scatter of the beam particles or the electromagnetic hf field exciting the instability. Such regularization has been brought about experimentally in several American laboratories. The possibility of exciting a regular strong wave of the nonlinear soliton type has been demonstrated. Ya. B. Faĭnberg[7] regularized a plasma-beam instability in an experiment by modulating the beam. The maximum fields estimated above have not yet been achieved in any of these experiments. The authors of the present paper point to new opportunities for regularization by using the nonlinear frequency decrease in systems having minima on the $\omega = \omega(k)$ dispersion curves.

5. Use of the properties of extreme-relativistic electrons to create deeper potential wells is of special importance. It is shown in[8] that in a relativistic electron beam with $\gamma = 1/\sqrt{1-\beta^2} \gg 1$, where $\beta = v/c$ (v is the velocity of the beam), i.e., a beam moving at a velocity near that of light, self-consistent stable potential wells formed by nonlinear waves that reach $2m_e c^2\gamma^2$ can exist in the laboratory system. Moving at nonrelativistic velocities in the laboratory system, such potential wells can trap and accelerate ions; their maximum electric fields are larger than that estimated above by $\sqrt{\gamma}$.

6. Control of the velocities of the potential collective wells is also of particular importance. The following methods may be used for this purpose: a) a decrease of beam density in space or an increase in the plasma density, which would result in an increase in the phase velocities of the waves in the plasma or a decrease in the beam, i.e., in an acceleration of the waves in the laboratory system in either case; b) use of an inhomogeneous decreasing magnetic field with buildup of cyclotron waves in the relativistic beam. Then $\omega_0/k = v - (\omega_H/k) \to v$, i.e., the waves are accelerated to the velocity of the beam[9]; c) use of external electric fields $E \ll E_{max}$, which accelerate the nonlinear relativistic waves to velocities near but not exceeding that of light, i.e., accelerate the nonlinear wave as a bunch[10].

7. An important possibility is that of using collective processes for autosynchronization of the collective acceleration[11]. This possibility arises out of the partial charge neutralization of the relativistic electrons. As a result, according to[11], the ions to be accelerated could create, with their charges, potential wells that are synchronous with their motion.

8. Another important possibility is that of a self-consistent increase in the potential wells as a result of dissipative loading of these wells by the ions being accelerated. This situation arises under conditions such that the potential wells are excited on negative-energy modes[9]. We proposed a similar principle in[12] for compression of a light electron beam by having a relativistic beam flow around it. Realization of these principles would permit an approach to solution of impact-acceleration problems[3].

All of these principles have been discussed or implemented to one degree or another in specific investigations. But their combined use promises a significant advance in the quite complex but important problem of creating new collective accelerators with energies of $1-10$ GeV and up to 10^{15} particles per pulse, plans for which are now being elaborated[9]. Nor can we exclude the possibility of transition to accelerating-pulse repetition frequencies of 1 to 10 GHz. Even in the forseeable future, therefore, collective linear accelerators will become a necessary research tool in the nuclear physics of low and medium energies. Research should be continued to establish the feasibility of such accelarators in high-energy physics.

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G. M. Drabkin, G. P. Gordeev, E. I. Zabidarov, Ya. A. Kasman, A. I. Okorokov, and V. A. Trunov. Investigation of Magnetic Ordering and Phase Transitions in Magnets by a Polarized-Neutron Method. The present paper is devoted to magnetic ordering near the phase-transition point in nickel[1], yttrium iron garnet[2], MnF_2, and Pd – Fe alloys[3], and is a result of research done over the last five years on a VVRM [Modernized Water-Moderated Water-Cooled Reactor] using beams of polarized neutrons. The polarized beams are produced either by total reflection from a magnetized ferromagnetic mirror or by Bragg reflection from a magnetized Co – Fe crystal. The experiments employed vector analysis of polarization and spectral polarization analysis using three pyrolytic-graphite crystals and consisting of simultaneous measurement of the depolarization of three monochromatic lines and a beam with a broad spectrum. The magnetization of the

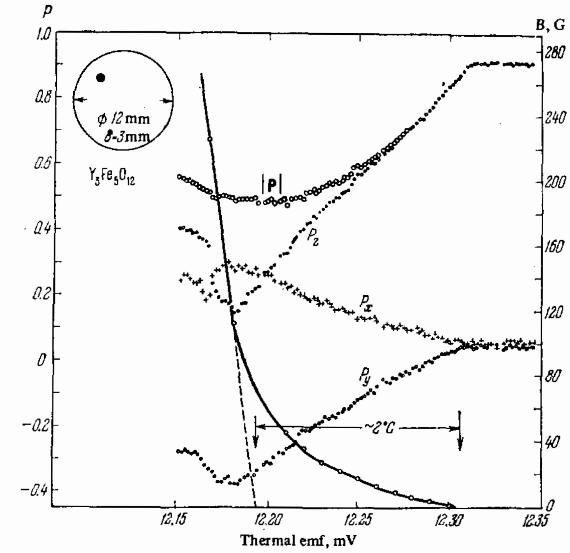

FIG. 1. Temperature dependence of the projections $P_{x,y,z}$ and the modulus |P| of the polarization of a neutron beam with a cross section of 1 mm² passed through a single crystal of iron-yttrium ferrite garnet near the Curie point. The solid curve is the temperature curve of induction in the specimen as reconstructed from these data. The heavy black dot in the circle indicates the point at which the beam passed through the circular specimen (diameter 12 mm and thickness 3 mm).

sample was measured from the rotation of the polarization vector (Fig. 1). The critical magnetic fluctuation and domain parameters were determined from the depolarization. The periodic magnetic structure was studied by the spatial spin resonance method. The small-angle magnetic scattering of neutrons was investigated simultaneously with the polarization analysis.

The spontaneous magnetization near T_C in Ni, determined from the depolarization of neutrons of various wavelengths, varies with temperature as $\tau^{1/2}$, where $\tau = (T_C - T)/T_C$, i.e., the critical exponent $\beta = 0.5$ in the relation $M \sim \tau^{\beta}$. Here the experiments indicate that, along with the small-scale inhomogeneity associated with the critical magnetic fluctuations and with the transition to the domain state, a large-scale inhomogeneity due to dipole interaction is observed in the transitional range.

The temperature superposition of the various phenomena complicates analysis of the experimental results and forces us to modify the experiments or to use narrow neutron beams for local study of the samples, or to conduct simultaneous investigations of the same sample by various methods. Such combined studies were made on samples of $Y_3Fe_5O_{12}$ by neutron, radio-frequency, and magnetic methods. Comparison of these data made possible more reliable establishment of T_C and more accurate determination of the critical transition exponents, which were found to depend on temperature. Thus, anomalously high values were found for the exponent β, which reaches 0.75 in the immediate proximity of T_C.

It was found possible to follow the dynamics of the observed phenomena as functions of the absolute value of the ordering parameter in a study of Pd – Fe alloys with variable concentrations of the magnetically active Fe atoms. Figure 2 presents experimental depolarization curves of neutrons passed through Pd – Fe alloys with iron concentrations from 0.5 to 8 at.%. Analysis of these data together with data on small-angle scatter-