The proposed mechanism of ion acceleration explains well a number of experimental facts [1]. For typical values $\varepsilon \simeq 1$ MeV (i.e., $\gamma = 3$), $I_0 \simeq 100$ kA, $r_0 \simeq 1$ cm, and $V \simeq 0.06\ c$ we obtain from formula (2) $\nu \simeq 10^9\ \text{sec}^{-1}$, which is likely for gas pressures $P_0 \simeq 1$ Torr. The linear dependence of the velocity V on the gas pressure, contained in (2), is also well confirmed experimentally (in the region $P_0 \simeq 0.2 - 1$ Torr). At the indicated beam parameters, according to (2) - (5), we obtain for the energy of the accelerated hydrogen ions $\varepsilon_H \simeq 4$ MeV, for deuterium $\varepsilon_D \simeq 8$ MeV, for carbon $\varepsilon_C = 25$ MeV; their relative scatter is $\eta \simeq 5 - 20\%$, and the intensity of the electric field on the ionization front is of the order of 5×10^6 V/cm. Finally, the total number of accelerated ions $N_i \simeq 10^{13}$ (at $z_i = 2$). These estimates agree well with the experimental data [1].

The comparison with experiment indicates that the proposed mechanism of ion acceleration is realistic, and at currents $I_0 \simeq 10^6$ A and electron energies $\varepsilon \simeq 10$ MeV it uncovers the possibility of accelerating $10^{15} - 10^{16}$ ions in a pulse to energies $\varepsilon_i \simeq 30 - 100$ MeV.

In conclusion the authors are deeply grateful to I.S. Danilkin for a discussion, and also to A.A. Kolomenskii, who called their attention to [2 - 4].

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CURIE TEMPERATURE AND SUSCEPTIBILITY OF AN AMORPHOUS HEISENBERG FERROMAGNET (HIGH-TEMPERATURE EXPANSION)

J. Schreiber and K. Handrich
Technical University, Dresden, East Germany
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1. The number of studies of properties of amorphous ferromagnets has increased recently. A review of work on this question can be found in [1 - 3]. Experiments show that ferromagnetism is possible also without crystalline order. Theoretically this question was first posed by Gubanov [4]. This was followed by calculation of the magnetization under definite assumptions [5 - 7]. The susceptibility was determined in the molecular-field approximation [5, 8] and also for an Ising ferromagnet with the aid of thermodynamic perturbation theory for small structure fluctuations [7].

2. In the present paper we calculate the susceptibility of an amorphous Heisenberg ferromagnet with the aid of a high-temperature expansion. To this end we use the so-called "lattice" model, in which the spins are at the lattice sites and the exchange integrals (between nearest neighbors) fluctuate

stochastically (see [6, 8]). If we introduce an exchange integral <I> averaged over the structure, then we can write

$$I_{ij} = \langle I \rangle + \Delta I_{ij} .$$

In the chosen structural model

$$\langle (\Delta I_{ij})^{2n+1} \rangle = 0, \quad \langle \Delta I_{ij} \Delta I_{ke} \rangle = \frac{\Delta^2}{2} (\delta_{ik}\delta_{je} + \delta_{ie}\delta_{kj}),$$

$$\langle (\Delta I_{12})^4 \rangle = \frac{\Delta^4}{4} + \alpha(4), \quad \ldots$$

Expanding the free energy

$$F = -\frac{1}{\beta} \langle \ln \mathrm{Sp} e^{-\beta \mathcal{H}} \rangle$$

in powers of β, we obtain from the susceptibility (see [9])

$$\chi = -\frac{\partial^2 F}{\partial H^2}\Big|_{H \to 0} = \theta \frac{\mu_B^2 g^2}{\langle I \rangle} N \frac{S(S+1)}{3} \sum_{n=0}^{\infty} \frac{a_n}{n!} \theta^n, \quad \theta \equiv \frac{\langle I \rangle}{kT}. \tag{1}$$

It is not necessary here to stipulate smallness of the fluctuations of the exchange integrals as in [7].

The coefficients a_n can be represented in the form $a_n = a_n^{(0)} + \Delta a_n$, with $a_n^{(0)}$ corresponding to the regular crystal (all the exchange integrals are replaced by <I>), and Δa_n is due to the fluctuations of the exchange integrals. For cubic lattices we have determined Δa_n up to n = 4.

3. For $\Delta^2/\langle I \rangle^2 \lesssim 1$ we can neglect terms Δ^4 and $\alpha(4)$ in Δa_4. We then get $\Delta a_n \leq 0$ for n = 1, ..., 4. By determining the radius of convergence of the series (1) we can obtain the Curie temperature [9]. We have used the following convergence criteria:

$$\mu_n^{(1)} = \frac{a_n}{a_{n-1}} \frac{1}{n}$$

and

$$\mu_n^{(2)} = \sqrt{\frac{a_n}{a_{n-2}} \frac{1}{n(n-1)}}.$$

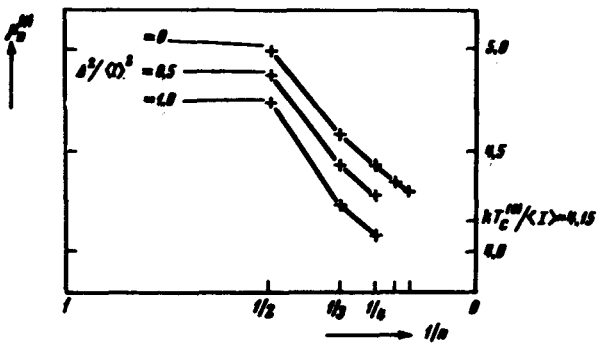
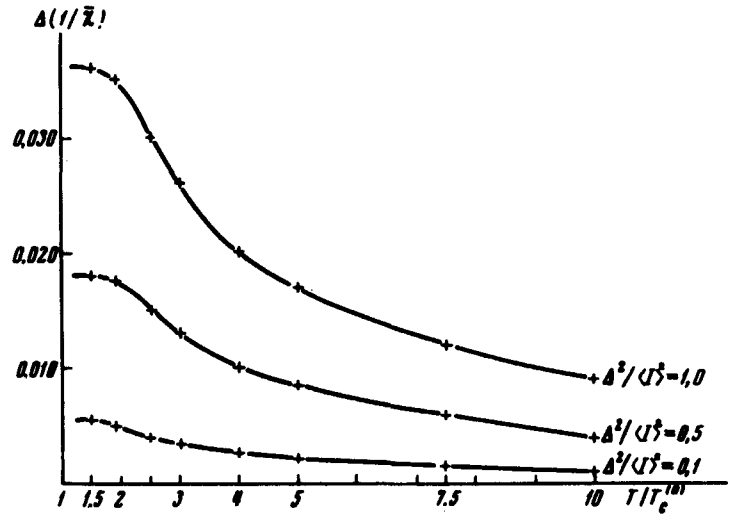


Fig. 1

From the representation $\mu_n = f(1/n)$ we can extrapolate T_c by comparison with the regular crystal (see Fig. 1). The accuracy for ΔT_c is several per cent. The result can be written in the form

$$T_c = T_c^{(0)} \left(1 - A(S, z) \frac{\Delta^2}{\langle I \rangle^2}\right),$$

Fig. 2



where $T_c^{(0)}$ is the Curie temperature of the regular crystal [9], S the modulus of the spin, and z the number of nearest neighbors. Calculation yields:

z	8			12		
S	1/2	1	3/2	1/2	1	3/2
$T_c^{(0)}$	2,660	7,550	48,500	4,150	12,000	75,400
$A(S, z)$	0,115	0,069	0,025	0,080	0,040	0,016
$\Delta T_c/(\Delta^2/J^2)$	−0,299	−0,521	−1,210	−0,332	−0,480	−1,210

It follows therefore that the fluctuations of the exchange integrals leads to a lowering of the Curie temperature, the latter corresponding to the results in [6] and [10]. In addition, for the case S = 1/2 and z = 12 we have determined

$$\Delta\left(\frac{1}{\bar{\chi}}\right) \equiv \frac{1}{\bar{\chi}} - \frac{1}{\bar{\chi}^{(0)}}; \qquad \bar{\chi} \equiv \frac{3kT_c^{(0)}}{\mu_B^2 g^2 NS(S+1)}\,\chi$$

as a function of the temperature (see Fig. 2). We see that the fluctuations of the exchange integrals lead to a decrease of the susceptibility for all T. This is in accord with the results of [7]. Calculations in the Weiss approximation [8] lead, to the contrary, to an increase of the Curie temperature and of the susceptibility. As shown in [10], this incorrect behavior follows from neglect of the short-range magnetic order in this approximation.

The authors are grateful to Professor G. Heber for useful discussions and valuable advice.

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MAGNETIC BREAKDOWN GIANT OSCILLATIONS OF ABSORPTION OF SOUND BY METALS

A.A. Slutskin and S.A. Sokolov
Novosibirsk State University
Submitted 26 April 1971; resubmitted 27 May 1971
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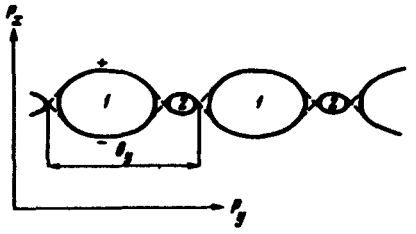
It is well known that the oscillatory dependence of different macroscopic quantities in metals on the magnetic field H is due to its quantizing properties. Usually, owing to the smallness of the quasiclassical parameter $\kappa = e\hbar H/cb_0^2$ (b_0 - characteristic dimension in p-space) the oscillations have a small amplitude $\sqrt{\kappa}$. However, the amplitude of the oscillations for the absorption of a sound wave (with frequency ω and wave vector q) under resonance conditions can become "giant," i.e., $\gtrsim 1$. This circumstance was first pointed out by Gurevich, Skobov, and Firsov (GSF) [1]. The GSF effect is due to oscillations of the density of the number of states on the Fermi surface at the point p_z, where there is resonance (p_z is the projection of the momentum on H = (0, 0, H))[1]. To observe this effect it is necessary to have a very small width of the resonance, namely [1] $\nu_0/qv_0 \lesssim \sqrt{\kappa}$ (ν_0 - collision frequency, v_0 - characteristic velocity).

In the present paper we show, using ultrasound as an example, that the phenomenon of magnetic breakdown [4] of interband tunnel transitions of a conduction electron in a field H leads to the occurrence of new giant (resonant) oscillations of the high-frequency characteristics of the metal, not connected with the oscillations of the density and differing strongly from the GSF effect. We consider as a model a system of periodically repeated symmetrical orbits of two bands, between which (at the locations of closest approach) there occur tunnel transitions with probability $W(\vec{H})$ [4, 5] (see the figure, where 1 and 2 are the numbers of the bands). In addition, it is assumed below that the electron spends most of the time on the trajectories of the first band, i.e., the reinforced inequalities $\alpha = S_1/S_2 \gg 1$ and $\beta = \Omega_1/\Omega_2 \ll 1$ are in force[2] ($S_{1,2}(E, P_z)$ - areas of orbits 1 and 2, $\Omega_{1,2} = eH/m^*_{1,2}c$ - the frequencies of revolutions on the orbits, $m^*_{1,2} = (2\pi)^{-1}(\partial S_{1,2}/\partial E)_{P_z}$, and $\alpha \sim \beta^{-2}$). Under conditions when stationary "magnetic-breakdown" states of the conduction electron are realized, and second orbit, in spite of its smallness, greatly influences the dynamics of the electron. Its "controlling" action (see below), due to coherent effects



[1] A similar phenomenon for electromagnetic waves was considered by I. Lifshitz et al. [2]. Some modification of the GSF effect was considered recently in [3].

[2] For a number of metals exhibiting the property of magnetic breakdown, $\alpha \lesssim 10^2 - 10^3$ [4].