We see that the change of T_C due to doping a dilute ferromagnetic alloy with nonmagnetic impurities is large and is directly connected with the average susceptibility if the nonmagnetic impurities change the susceptibility in nonlocal fashion. On the other hand, if the susceptibility changes locally, then this hardly affects T_C even though the average susceptibility may be strongly altered. Measurement of T_C can therefore yield information on the state of the nonmagnetic impurities in such alloys. This question has not yet been answered for a number of alloys.

According to [3], when 6% of tin is added to the alloy Pd + 2%Co, the value of T_C drops from 94 to 20°K. This is apparently due primarily to the decrease in the density of state, which is connected with the increase in the number of electrons in the d-band (in analogy with the PdAg alloy). The determination of R_0/γ in the PdCo alloy from the dependence of T_C on n (R_0/γ = 3.3 Å) makes it possible to describe the dependence of T_C on the tin concentration, observed in [3], by using formula (7) and assuming $D \simeq 25$, i.e., $F_1 - F_2 \simeq 2.5$, which is quite reasonable.

We thank N. E. Alekseevskii and Yu. A. Samarskii for communicating the results of [3] prior to publication.

[1] T. Moriya, Progr. Theor. Phys. 34, 329 (1965).
[2] I. Ya. Korenblit and E. F. Shender, Zh. Eksp. Teor. Fiz. 62, 1949 (1972) [Sov. Phys.-JETP 35, 1017 (1972)].
[3] N. E. Alekseevskii and Yu. A. Samarskii, ibid. 64, 1342 (1973) [27, No. 4 (1973)].
[4] N. E. Alekseevskii, Yu. A. Samarskii, A. P. Kir'yanov, and V. I. Tserbo, ZhETF Pis. Red. 8, 650 (1968) [JETP Lett. 8, 403 (1968)].
[5] P. Lederer and D. L. Mills, Phys. Rev. 165, 837 (1968).

SUPERCOMPRESSION OF MATTER BY REACTION PRESSURE TO OBTAIN MICROCRITICAL MASSES OF FISSIONING MATTER, TO OBTAIN ULTRASTRONG MAGNETIC FIELDS, AND TO ACCELERATE PARTICLES

G. A. Askar'yan, V. A. Namiot, and M. S. Rabinovich
P. N. Lebedev Physics Institute, USSR Academy of Sciences
Submitted 1 August 1972; resubmitted 20 April 1973
ZhETF Pis. Red. 17, No. 10, 597 - 600 (20 May 1973)

We consider the attainment of very low critical masses of fissioning matter by supercompression with reaction pressure from high-temperature evaporation of matter. It is indicated that such microcritical masses can be used to obtained pulsed streams of neutrons, neutrinos, etc. The possibility is indicated of obtaining ultrastrong magnetic fields ($\gtrsim 10^9$ Oe) by supercompression of matter and acceleration of particles.

Evaporation of matter by powerful radiation and current can result in colossal optical-reaction pressures [1].

Much attention is being paid of late to the idea [2] of increasing thermonuclear yield by superdense compression of hydrogen by optical-reaction pressure.

In this article we propose to use such supercompression of matter to solve two other problems - to obtain microscopic critcal masses of fissioning heavy elements by more effective neutron multiplication accompanying an increase in the density of the fissioning matter, to obtain ultrastrong magnetic field, and to accelerate particles.

1. *Obtaining Microcritical Masses of Fissioning Matter*

Since the neutron free path prior to multiplication is $\ell_f \simeq 1/n_i\sigma_f$, where n_i is the density of the nuclei and σ_f is the cross section of the fission reaction, it follows that increasing the concentration of matter can greatly increase the effective utilization of the fission neutrons, decreasing thereby the critical dimensions $L_{cr} \sim \ell_f \sim 1/n_i$ and the critical masses ($M_{cr} \sim n\ell_f^3 \sim 1/n_i^2$).

Assume that powerful laser radiation acts from all sides on the surface of a particle of fissile material (in many cases it is more convenient and more expedient to have the laser act on a so-called ablation coating - a layer of matter producing the optimal optical-reaction pressure coated on the surface of the fissioning body.

The pressure produced by evaporation is [1]

$$p \approx \dot{M} v_{\text{escape}} \simeq [I/(\lambda + v^2)]\, v \simeq (I/v) \sim I^{2/3} \rho^{1/3},$$

where λ is the specific heat of evaporation and ionization, v is the escape velocity, ρ is the density of the material. For example, a hundred-fold compression yields $p \approx 10^{11}$ atm at $I \approx 10^{17}$ W/cm^2, corresponding, for example, to an energy release $Q \approx 10^2$ kJ in 10^{-9} sec on an area $\sim 10^{-3}$ cm^2.

In the case of a degenerate electron gas, such a pressure corresponds to a concentration of the nuclei

$$n_i \approx \left(p \frac{m}{\hbar^2}\right)^{3/5} \frac{1}{Z_{\text{eff}}} \approx 10^{25} \text{ ion/cm}^3,$$

where $Z_{\text{eff}} \approx 10$ for ionization of the two upper electron shells at not very high temperatures, $T_e \le 500$ eV. At such concentrations of the nuclei, the free path of the neutrons prior to fission is $\ell_f \sim 1/n_i\sigma_f \approx 3\times10^{-2}$ cm, since usually $\sigma_f \approx 1 - 2$ b for the fast-neutron energies and types of material of interest to us.

An ablation coating can be used not only to decrease the consumption of fissioning matter and to increase the evaporation pressure, but also to reflect the neutrons inside the working volume. The coefficient of neutron reflection from a supercompressed ablation coating (made, e.g., of hydrogen, which has a high neutron-scattering cross section, $\approx 1 - 3$ b) can be made of the order of unity:

$$\alpha \approx n_i \sigma_{tr} \ell,$$

where $\sigma_{tr} \approx 2$ b and $n_i \approx 10^{26}$ ion/cm^3, $\ell \approx 3\times10^{-3}$ cm. (We note that at the same pressures the concentration of the nuclei in the compressed hydrogen facing can exceed by one order of magnitude the concentration of the nuclei of the compressed fissioning matter, owing to the better compressibility of the hydrogen.)

The neutron multiplication can be estimated by using the simplified equation

$$R\frac{dn_n}{dt} \approx R\nu n_i n_n \int [\sigma_f(v_n) - \sigma_a(v_n)]\, f(v_n)\, v_n\, dv_n -$$
$$- n_n \int v_n f(v_n)\, dv_n,$$

where $\nu = \nu_0 - 1$ is the excess multiplication coefficient, $f(v_n)$ is the neutron energy distribution function, σ_f is the fission cross section, and σ_a is the cross section for absorption without fission, i.e.,

$$R\frac{dn_n}{dt} \approx R\nu n_i n_n \overline{\sigma_f v} - 3 n_n v_n$$

i.e., the supercriticality condition

$$R_{cr} \approx 3/\nu n_i \sigma_f.$$

Taking the neutron reflection into account, we have

$$R_{cr} \approx 3(1-\alpha)/\nu n_i \sigma_{f\,\text{eff}},$$

where the reflection coefficient is $\alpha \approx n_i\sigma_{tr}\ell \sim 1$.

These estimates show that it is possible to obtain critical dimensions $R_{cr} \sim 10^{-2}$ cm and a mass $M_{cr} \sim 10^{-2}$ g. At a one-percent fraction of the reacting nuclei, this corresponds to an energy release $\sim 10^7$ J, many times the energy consumed in the compression of the material ($\tilde{<} 10^2$ kJ).

The time of energy release from a neutron cascade is $\tau_n \approx K/n_i\sigma_f v_n$, i.e., $\tau \sim 2K\, 10^{-11}$ sec; for example, if the number of the last generations, which are of greatest importance for the energy release, is $K \approx 3$, we get $\tau \approx 6\times10^{-11}$ sec.

The divergence time $\tau \gtrsim a\sqrt{\rho/p} \gtrsim a\sqrt{4\rho a^3/Q} \simeq a^{5/2}\sqrt{4\rho/Q} \sim 10^{-10}$ sec exceeds the time during which the cascade terminates, and can not weaken the effectiveness of the cascade development.

Pulsed microcritical masses can be used to obtained pulsed neutron and neutrino fluxes of high intensity ($\sim 10^{17}$ neutrons in 10^{-10} sec), which are of interest for a number of physical experiments.

2. *Obtaining Superstrong Magnetic Fields by Supercompression of Matter with Reaction Pressure*

Strong compression of matter can be used to compress a magnetic field frozen into matter or confined in a cavity inside matter subject to compression (in analogy with the implosion method proposed by Academician Sakharov for obtaining strong magnetic fields [4]). The large evaporation pressure, $10^{11} - 10^{12}$ atm, is equivalent in its action to a magnetic field intensity $H \simeq \sqrt{8\pi p} \simeq 3\times10^9$ Oe, but the really attainable value of H is determined from the geometry of the compression. In the case of compression of a solid body, the change of the cross section is $S_0/S \simeq (n/n_0)^{2/3} \simeq 10^3$ with the concentration changing by 3×10^4 times. Assuming the flux to be constant, we obtain a field enhancement $H/H_0 \simeq S_0/S \simeq 10^3$, which yields $H \simeq 10^8 - 10^9$ Oe at an initial field $10^5 - 10^6$ Oe.

The short compression times ($\lesssim 10^{-10}$ sec) and the high temperatures ($T \sim 1 - 3$ keV) yield a skin time $t \simeq 4\pi\sigma R^2/c^2 \simeq 10^{-7}$ sec $\gg t_{collapse}$ (at $\sigma \sim AT^{3/2} \sim 10^{17}$ cgs esu and $R \simeq 10^{-2}$ cm), i.e., the magnetic field does not have time to diffuse from the material upon compression. Large cross-section compression coefficients can be obtained by compressing hollow bodies.

The large induced electric fields $E \sim R\dot{H}/2c \simeq 10^9$ V/cm can ensure near the surface electron and ion acceleration to energies $\varepsilon \simeq ZeHR \simeq 3Z$ GeV upon compression to fields $H \simeq 10^9$ Oe (Z is the effective charge of the particle).

The authors are grateful to the late Academician L. A. Artsimovich and Academicians M. A. Markov and A. M. Prokhorov for collaboration in the development of this work.

[1] G. A. Askar'yan and E. M. Moroz, Zh. Eksp. Teor. Fiz. 43, 2319 (1962) [Sov. Phys.-JETP 16, 1638 (1963)].
[2] E. Teller, Paper at Seventh Conf. on Quantum Electronics, Montreal, May 1972.
[3] G. T. Seaborg and J. L. Bloom, Scientific American 225, No. 5, 13 (1970).
[4] A. D. Sakharov, Usp. Fiz. Nauk 88, 725 (1966) [Sov. Phys.-Usp. 9, 294 (1966)]; Ya. P. Terletskii, Zh. Eksp. Teor. Fiz. 32, 387 (1957) [Sov. Phys.-JETP 5, 301 (1957)].

ERRATUM

In the article by Yu. V. Orlov and V. B. Belyaev (Vol. 17, No. 7, p. 276) it is necessary to introduce into the formula for the connection between G_t^2 and C^2 (in the footnote on p. 277) a factor 1/2 (furthermore, λ should be replaced by λ^2). Accordingly the constant G_t for a Reid potential is equal to 1 F, and not 2 F as indicated in the article. On p. 278, line 14 from the top, read DG instead of DT.