Sakharov's achievements

SIR—Ernest B. Gliner's letter "Another reason for saving Sakharov" (*Nature* **318**, 513; 1985) notes only his work on gravitation. His major contributions in particle physics, fusion research and cosmology[1] provide additional evidence that Sakharov's scientific contributions will be remembered, like those of Galileo, long after the names of those who persecuted him are forgotten. Perhaps the new Soviet leaders will note that their grandchildren may study the work of this great Russian physicist and wonder about the role of their grandfathers in his persecution.

In 1950 Sakharov proposed a solution to fusion's major problem: how to contain the reaction at its enormously high temperatures where no known materials can survive. Sakharov's "magnetic bottle", called the "tokomak" (ref. 1, p.49), which uses magnetic forces to contain the hot fusion fire, is currently the front-line approach to fusion reactors and may go down in history as man's answer to the energy crisis.

Sakharov's two remarkable 1966 papers on particle physics were far ahead of their time. Sakharov and Ya. B. Zeldovich (ref. 1, p.271; ref. 2) obtained relations between masses of different known particles in surprising agreement with experiment by assuming the new quark theory of matter which built all these particles from the same three basic building blocks arranged in different combinations, and held them together by forces which, although unknown, were always the same in different particles. Sakharov's work was ignored because the physics establishment did not take quarks seriously at that time.

Even more remarkable was Sakharov's resolution in 1966 of the apparent contradiction between the "big bang" theory of the origin of the Universe and the failure of astrophysical observations to reveal any trace of antimatter in the Universe. In his theory, the antimatter created in equal amounts with matter in the big bang decayed more rapidly than matter, leaving the observed excess matter. Sakharov demonstrated (ref. 1, pp.147, 151) three necessary conditions for this mechanism: (1) the recently discovered CP violation asymmetry between the interactions of particles and antiparticles; (2) a departure from thermal equilibrium; (3) violation of the law of baryon number conservation. This required the proton to be unstable and to decay into electrons and mesons, but so slowly that proton decay would not have been detected in any experiments.

His theory was not accepted because of a number of assumptions ridiculed as crazy at the time: (1) the existence of new very heavy boson particles; (2) the existence of quarks and of new interactions between quarks, electrons and these new heavy bosons; (3) violation of the sacred principle of baryon conservation.

Today Sakharov's theory is the accepted view on the antimatter problem, his crazy assumptions are now a central part of the standard theories, and his three conditions are accepted as necessary for any cosmological model. Quarks, new heavy bosons which allow protons to change into electrons, violation of the law of baryon conservation and predictions that the proton must decay are all essential ingredients of the new "grand unification" theories. Many large expensive experiments are searching for Sakharov's predicted proton decay.

Even in his isolation in Gorki he has managed to continue the development of his 1966 ideas into new work on the quark theory of matter[3] and the cosmology of the early Universe[4]. His continual hopes for freedom in the Soviet Union and an end to the nuclear arms race seem like wild dreams. But we can all hope that once again Andrei Sakharov is right and only 10 years ahead of his time, and that the new Soviet leaders will allow him to return to Moscow with free access to scientific libraries, institutes and personal contacts so that he can pursue his work freely for the benefit of all mankind.

HARRY J. LIPKIN
High Energy Physics Division,
Argonne National Laboratory,
9700 South Cass Avenue,
Argonne, Illinios 60439, USA

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Open house

SIR—In your article "What price freedom?" (*Nature* **319**, 608; 1986), you say that "IUPPS is affiliated to a UNESCO umbrella organization which advocates an academic boycott of South Africa". This point needs to be clarified. The International Union of Prehistoric and Protohistoric Sciences (IUPPS) is affiliated to the International Council for Philosophy and Humanistic Studies (CIPSH). CIPSH has considered itself bound by UNESCO policy and will not give funds either for activities taking place in South Africa or to persons falling under the jurisdiction of South Africa.

CIPSH, however, believes that international congresses should be open to all bona fide scholars, irrespective of domicile, race, religion or belief. This policy was set out in an exchange of correspondence between the secretary-general of CIPSH and the secretary-general of IUPPS in August 1985, specifically in response to Professor Ucko's enquiry to the latter as to the official attitude of IUPPS and CIPSH towards the participation of persons working in South Africa in the activities of IUPPS. Moreover, the CIPSH bureau, at its meeting in Istanbul about the beginning of December 1985, reiterated this CIPSH policy and indicated that the organizers of the Southampton congress should take every precaution to ensure the free participation of all in their activities.

Failing such arrangements, the bureau resolved, the organizers of the congress would be entitled to cancel the holding of the meeting, since it would not be able to ensure completely free participation and academic freedom.

In this attitude, then, it does not seem that the policy of CIPSH "advocates an academic boycott". On the contrary, its policy towards international congresses seems to square with that of the International Council of Scientific Unions (ICSU): both parties favour the free circulation of scientists and an "open house" participation in international congresses.

PHILLIP V. TOBIAS
Department of Anatomy,
University of the Witwatersrand
Medical School,
York Road, Parktown,
Johannesburg 2193, South Africa

Too many fourth states of matter?

SIR—In the short period of time between May and October last year, I see that the 'fourth state of matter" was referred to in *Nature* in two book reviews, one on plasma physics[1] and the other on polymers[2]. The same phrase has been used in connection with the discovery of icosahedral symmetry.

Physicists should realize that if there is such a thing as the fourth state of matter, there can be only one of it. Moreover, physicists should be aware that in 1940 the attribution was used to describe the superfluidity of helium-3 (refs 5, 6). But the phrase has also been used to describe other kinds of superfluidity such as in the superconducting state of electrons[7].

Is there a danger that this practice will get out of hand?

J.M. GOLDSCHVARTZ
Clavecimbellaan 273,
2287 VK Rijswijk zh,
The Netherlands

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