'Cooled Protons Promise Energy— A Technique Perfected In Siberia'

We reprint here a full translation of the article, "Cooled Protons Promise Energy — A Technique Perfected in Siberia," by Ugo Amaldi, which appeared in the Science and Technology Section of the Milan newspaper Corriere della Sera on Feb. 9.

Last summer Soviet plasma physicist Rudakov revealed a dramatic contribution to controlled thermonuclear fusion research with his advances in electron beam technology. Now his colleague Budker has made an equally significant contribution as reported in the Correire della Sera *article.*

Budker used a non-linear plasma effect to increase the degree of order in a high energy beam of protons. If increased ordering allows the proton beam to be focused to extremely high densities, this effect is very useful for controlled thermonuclear research where such beams can be used to compress and heat fusion fuel as well as for fundamental theoretical research.

Over the last few months, particle accelerator experts have enthusiastically received the news that at Novosibirsk, in Siberia, Professor Budker has succeeded in "cooling" a bundle of protons through the application of a method which he himself proposed about ten years ago. This method involves the use of an electron bundle.

This success deserves to be known because the new technique is not only applicable in the area of fundamental research carried out with the use of particle acclerators, the aim which Budker had in mind when he proposed it, but is apparently also susceptible of interesting developments in the search for new ways to produce energy through nuclear fusion.

Parallel Bundles

The term "particle bundles" is currently used not only in research regarding fundamental particles and their interactions, but also in practical applications, such as the radiation of surgical instruments as a means of sterilizing them and in tumor therapy. Whatever the source and the use of a "bundle," it is not possible to make the particles of which it is composed all move along exactly parallel trajectories.

The new "cooling" technique through the use of electron bundles allows for a very large reduction of the intrinsic divergence of the proton bundles produced by the particle accelerator. It should be added at this point that the mechanism has nothing to do with the principle of the laser, which is only applied to bundles of visible light.

In the accumulation ring constructed by Gersh Budker and his collaborators, there is a bundle of protons of 65 billion electron volts of energy in continuous circulation. The ring is shaped like a horse racetrack, the greater sides of which measure about five meters. Each of these sides is formed by a straight tube in which the protons move along approximately parallel trajectories and with the energy levels of each differing somewhat. At the same time a bundle of electrons is passed through one of these tubes (the energy of the electrons is such that their velocity is equal to half the velocity of the protron); since the mass of an electron is nearly 2000 times smaller than that of a proton, in order to make the electrons more parallel to and at the same speed of the protons it is necessary to impart to them about 2000 times less energy. The two bundles travel mixed together in the straight tube, moving at approximately 100,000 kilometers per second; while the protons themselves move the length of the ring and traverse the same path millions of times per second, the electrons are hurled off at each passage and substituted by continuously new electrons.

The electrical forces which are exercized between this cloud of electrons and each proton cause the latter to gain velocity, if it (the proton) is moving too slowly with respect to the electrons, or to lose velocity if it is going too fast.

As predicted by the theory developed ten years ago, Budker and his collaborators have observed that in less than a tenth of a second the trajectories of the protons become much more parallel and their respective energies become practically all equal. The presence of the electron bundles therefore reduces the dispersion of velocities and directions of motion of the protons: in technical language, the electrons "cool" the protons.

What are the applications of this new technique? The most immediate deal with particle accelerators and the fundamental research which utilizes these instruments. The more a bundle is composed of particles moving along parallel trajectories and with similar energies, the smaller the area on which it can be focused using appropriate lenses. A cooled bundle can therefore be concentrated on much smaller dimensions than could a non-cooled bundle, as long as it is focused through lenses to which the electrically charged particles are sensitive — that is, magnetic lenses.

Microexplosions

Electron cooling opens up new perspectives for the study of proton-antiproton interactions. It is now possible to conceive of the realization of the particle accelerator which Budker proposed ten years ago. Now pre-cooled bundles of protons and antiprotons will be able to cir-

culate in opposite directions in one and the same magnetic ring of a few kilometers in diameter. Powerful magnetic lenses will be focused on one or two points of the circumference on dimensions of the order of a millimeter such that the number of proton-antiproton interactions will be much greater than could be obtained were the bundles not cooled.

A project of this type was begun in the last weeks at the European Center for Nuclear Research in Geneva; most of the credit goes to a brilliant Italian physicist, Carlo Rubbia. The same is happening at the Fermi Laboratory in Chicago. Within one year, prototypes of the cooling rings will be in operation.

The possibility of producing intense bundles of charged heavy particles which can be focused on very small surfaces has been received with great interest by accelerator experts who one or two years ago decided to contribute to the attempts to solve the energy crisis. There exist methods of energy production which are based on the realization of microexplosions of the H-bomb type. In these methods there is an attempt to compress gold capsules one millimeter in diameter which contain deuterium and tritium until (temperatures of) 100 million degrees are reached. The deuterium and tritium nuclei can in fact supply energy by fusing if these temperatures are reached.

The energy for the comparison process is supplied by a large number of laser bundles which are simultaneously focused on one of these microspheres. Until now, the attempts have been to use lasers because of the enormous quantity of energy which they can concentrate on (surfaces of) very small dimensions, but this process is still far from achieving success.

In the last year various sources have proposed using bundles of iodine or uranium ions instead of laser bundles. One of the problems to be solved, however, deals with the possibility of focusing these extremely intense bundles on such tiny dimensions. Pre-cooling with electrons can solve the problem.