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COULD ANTIPROTONS BE USED TO GET A HOT, DENSE PLASMA?

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It is well known that the developments in experimental technique dictated by the needs of nuclear physics have often resulted in some applications in other fields of science. For instance, nuclear reactors are exploited intensively now by solid-state physicists. Meson factories are also attracting attention as very useful tools for solid-state physics, chemistry, and medicine. A remarkable evolution can be observed in electrostatic tandem generators which are used as mass spectrometers. Here, for example, a further success was achieved in ^{14}C dating with implications for other isotopes.

Of course, it might appear irrelevant to compare LEAR with electrostatic tandem generators because of the much higher cost of producing antiprotons. No doubt, only those experiments should be considered seriously which could provide us with valuable information and cannot be done at other less unique facilities.

What is specific to LEAR is the high beam quality which is comparable to that for protons at electrostatic tandem generators, with the possibility of accumulating a sufficiently large number of antiprotons in the storage ring. This reveals an opportunity to obtain an enormous energy release in a small volume, which could result in microexplosions. In fact, now the greatest interest in the study of microexplosions is shown by those physicists who are trying to use practical lasers both for feasible fusion power reactors and to produce X-ray lasers.

The most efficient way of studying microexplosions at LEAR would be to produce a dump of antiprotons stored in LEAR on a target of a fissile isotope. In this case annihilation of stopped

Fig. 1 Specific ionization along the antiproton path

antiprotons should be accompanied by fission, with the total kinetic energy of the fission fragments being about 160 MeV. Figure 1 shows a significant increase in energy released near the point where an antiproton is stopped. The shaded area corresponds to the energy of fission fragments, both light f_L and heavy f_H . For the number of dumped antiprotons equal to 6×10^{11} , about 16 J should be released during 10^{-6} s. Owing to the small size of the beam, this energy should be concentrated inside a small volume. A rough estimate shows that for a beam of antiprotons with a momentum of 300 MeV/c, antiprotons will stop in 0.2–0.4 mg of uranium. Therefore the power per unit of weight is equal to $\sim 5 \times 10^4$ MW/g, which is many orders of magnitude higher than that inside the fuel rods in the most powerful nuclear reactors.

In order to understand why it might be interesting to study microexplosions induced by bursts of antiprotons, it is useful to recall some ideas concerning laser-induced fusion. It is considered now as one of the most promising ways of obtaining a hot plasma compressed to high pressures with pulsed irradiation of small hollow spherical pellets using focused beams of laser light^{1,2}. It is

supposed that "light pressure" could be 10^8 atm, but much higher pressures can be generated by ablation and implosion. It was estimated that less than 10^3 J of light energy would appear sufficient to arrive at extremely high pressures¹.

Of course energy released at a dump of antiprotons (~ 10 J) is much lower than that in the case of lasers; also, with the present version of LEAR, pulses will be longer than those shaped with lasers. At the same time, however, quite different conditions of microexplosions could be realized in experiments with antiprotons. Antiprotons before being stopped can penetrate deep inside a solid target. This allows some new approaches to the study of microexplosions. For example, microexplosions in a small cavity covered with a thin layer of uranium might be of interest. Hopefully the momentum flux associated with fission-driven ablation would be high enough to induce the compression of a gas or a liquid inside the cavity. By splitting an antiproton beam extracted from LEAR, with subsequent focusing, probably better pulse shape could be achieved.

REFERENCES

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2. M.H. Key, *Phys. Bull.* 33, 95 (1982).