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SUMMARY ON POLARIZED TARGETS

S. Mango

Swiss Institute for Nuclear Research (SIN)
CH - 5234 Villigen, Switzerland

Polarized targets in operation at high and medium energy physics laboratories are almost without exception dynamically polarized, using a dielectric solid doped with paramagnetic radicals; this requires that the target be maintained at low temperatures in a relatively high and homogeneous magnetic field. They feature a high density of polarized nuclei, a relatively high degree of polarization and a polarization reversal capability, but they contain also unpolarized and/or polarized "background" nuclei. The polarization can be sustained only if the beam hitting the target does not warm it up, which sets rather low limits to the beam intensity, and in any case the polarization decays with the accumulated dose, due to radiation damage.

The frozen spin technique allows easing of the constraints set by the high and homogeneous magnetic field, but at the expense of a further reduction of the allowed beam intensity and of a more elaborate technical set up. The advent of irradiated NH_3 and ND_3 as target materials, in place of the traditional chemically doped alcohols and diols, has increased by a large factor the life time in the presence of intense ionizing beams.

Nevertheless, limitations remain, and new schemes continue to be devised and investigated to overcome them. Basically, all propose a polarized atomic beam, or jet, or stored atomic gas; they would consist only of the nuclei of interest, be insensitive to beam degrading and practically transparent to the incident beam. Their density would be orders of magnitude lower than for solid targets. Polarized targets of such a type could therefore be used not only at the end of an external beam like the "solid" polarized targets, but also internally in accelerators and storage rings. Work is in progress in several laboratories, and it is hoped that it will not be long till the first system becomes operational.

"Solid" polarized targets still remain the instrument of choice for many experiments with external low intensity or neutral beams. Reports have been presented on work being done with the aim of improving one or other feature of dynamically polarized targets. The Saclay group reported progress in their effort to reproduce in large samples of irradiated ^{7}LiH and ^{6}LiD the high degrees of polarization achieved by the group of Prof. Abragam in thin samples of a few cubic millimeters. While for high energy physics experiments polarized ^{6}LiD would give a good polarized neutron target, it has been speculated that polarized ^{7}LiH could similarly give a good polarized target for inclusive reactions on polarized protons. For lower energy physics, ^{6}LiD would be of immediate interest for the high degree of deuteron polarization achievable, much higher than in the presently used deuterated target materials, albeit in a magnetic field of 6.5 Tesla. In the quest for higher tensor polarizations in deuterated compounds, the Bonn group reported preliminary, but very promising results of enhancement by "hole burning" in vector polarized irradiated single crystals of ND_3. It is hoped that these two groups reach their goals soon, so that new classes of particle physics experiments become possible.

From the University of Michigan group at BNL, confronted directly with the problem of dealing with high intensity proton beams, came further data for an optimized operation of a ^{3}He/^{4}He evaporation cryostat, in which proton polarizations of 55% in irradiated NH_3 could be sustained in presence of $\sim 10^{10}$ protons/sec., and a report on the construction and preliminary tests of a cryostat in which the target is kept in a ^{4}He bath, cooled by contact with a pumped ^{3}He bath. Technical difficulties prevented the completion of a thorough set of measurements to assess the validity of this idea suggested long ago.

In the context of polarized targets exposed to intense beams, if one will not or can not go to configurations like 5 Tesla / 1 K, an exciting possibility could be seen in the work on microwave induced optical nuclear polarization (MIONP) pioneered at Leiden and reported by W.Th. Wenckebach. Provided that radiation induced paramagnetic centers would not bring unacceptably fast relaxation rates too quickly, one could speculate e.g. on a frozen spin target at ^{4}He temperatures, with inherent beam heating dissipation capability. In any case, the prospects opened up by MIONP of frozen spin targets at high temperatures deserves to be pursued with increased intensity; higher degrees of polarization should be demonstrated and research extended to other materials, better suited for use as polarized targets than the ones in which 42% proton polarization at 2.7 Tesla and 1 K have been already achieved.

When looking at the future, we should not forget the present and the past. H. Glaettli reminded us that not only protons and deuterons, but many other nuclei can be and have been dynamically polarized, and presented a comprehensive list of them; J.A. Konter brought up the large class of nuclei which can be polarized by static polarization methods; D. Vandeplassche reported on nuclear polarization by pick up of polarized electrons from ferromagnetic crystals; Mrs M. Leduc reported on recent progress in polarizing ^{3}He gas by optical pumping using infrared tunable lasers.

These contributions concerning exotic nuclei, as far as high energy particle physics is concerned, show not only the possibilities of dynamic nuclear polarization for nuclear physics targets (till now neglected), but also should make it clear that other polarization methods do exist, are being used in other fields of physical research, and are being or could be improved.

Finally, the contribution of W. Knop and T.O. Niinikoski on the use of polarized targets in biological structure research, made possible by the demonstration of the polarizability of the protons of macromolecules dissolved in mixtures of heavy water and deuterated glycols doped with Cr^V compounds, showed an unexpected and exciting new application of dynamic nuclear polarization.

As a conclusion, I would like to say that the challenge of polarized targets suited for any type of experiments has still to be matched (if it will ever be). In the meantime we should try to have as many experiments as possible being done, employing and improving existing techniques and developing new ones, with the help of hard work and imagination.