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Thin Film Coatings Which Inhibit Spin Relaxation of Polarized Potassium Atoms*

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Introduction

It has been discussed by Holt et al. 1) and Holt 2,3,4) that polarized internal targets in storage rings should be a powerful method for the study of nucleons and nuclei. This method should be compatible not only with existing electron rings but also with the recently proposed linac-stretcher ring accelerator design of MIT 5). At present, laser-driven polarized targets appear to be the most promising technology under consideration.

A prototype of a polarized deuterium target which employs the spin-exchange method, see reference 6, 7 for detailed calculation by Green, is being developed at Argonne National Laboratory as illustrated in Fig. 1. The target polarization can be detected by the $D(^3He,p)^4He$ reaction. A 625-keV ^3He beam was incident upon the gas jet of deuterium atoms and the ~ 14 MeV protons were counted in Si surface-barrier detectors. At the $3/2^+$ resonance this reaction exhibits a 0.7-b cross section as shown by King 8) and maximum analyzing power as shown by Ohlsen 9) for t_{20} and thus is ideal for the study of a thin tensor polarized deuterium target. A field of ~ 4 gauss was maintained near the target to provide an orientation axis for the spin state of deuterium and K. The mixing cell was heated in an oven to ~ 500°K in order to vaporize the K.

The cell is a critical component of this system. Deuterium atoms enter from the side of one end and K vapor from the other side. The laser beam

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enters the K-D mixing cell through the optical window and polarizes the K atoms and they in turn polarize the deuterium atoms by spin-exchange scattering. It is critical that there is a surface that will reflect these atoms many times and that this surface not be destroyed by the K as it is a very corrosive material. Also, a vacuum of ~ 10^{-7} Torr. must be maintained to prevent the reflecting surface from being oxidized. The polarized K atoms exit the cell from the other end of the mixing after an average of approximately 1000 wall bounces.

Thin Film Coating Methods

Since H atoms have long spin-relaxation times 10) on a teflon surface, one of the reflecting coatings tried was a teflon product produced by DuPont 11) called PTF-852-201 Line. In this method, the solution was diluted with distilled water by ~ 3:1. The cell to be coated was first cleaned with ethyl alcohol and then distilled water using an ultrasonic cleaner. Then painted carefully the thin coat of solution was applied with a swab only onto the surface of the oxidized Al cell which was exposed to the K and then it was heated to 375°C for ~ 30 minutes. A second thin coat was applied and reheated to ~ 415°C for 30 minutes. None of the tests using this coating on the cells were successful owing to the rapid chemical reaction rate of potassium with teflon.

The most successful method for coating metal was that using drifilm 12) as suggested by Anderson and Swenson 13). After cleaning, the cell was placed in solution A [(Dimethyl dimethoxysilane $(CH_3)_2$ $Si(OCH_3)_2$], and then solution B [(Trimethylmethoxysilane $(CH_3)_3$ $SiOCH_3$], was poured gently on top and the acetic acid was added. Two distinct layers of solution were seen, but these will gradually reacted with each other. The cell was removed from the

container and baked under vacuum (10^{-5} Torr) at 220°C for 3 hours. It takes 24 hours to achieve the required first layer of drifilm reflector needed. After observation it may be determined that a second thin layer may be needed. Drifilm was applied to both a Cu and an anodized Al cell.

Technique for Coating Pyrex

The pyrex optical windows on the mixing cell must also be coated with drifilm. The technique for coating pyrex is quite different then that for metal. It is advisable to use a good fume hood for the glass (pyrex) coating. The pyrex is first cleaned thoroughly. Next, approximately 10ml of SC-77 solution 14) was poured into a glass container having a glass cover, (i.e. beaker with a watch glass). The part was placed in the container and (approximately 5 ml) of distilled water was added and covered. The parts were allowed to sit at room temperature for approximately 15 minutes. A thick mist formed on top of the solution after the water was added. As with the metal cell, the part was removed from container and baked under vacuum (10^{-5} Torr) at 220°C for 3 hours. A thin coating was observed on the surface of the glass.

This coating procedure for glass was also tried on an anodized Al mixing cell. A good test for a coated surface is how well water beads upon it. Although the surface looked coated and water beaded up on it, the coating did not have good vacuum properties and our tests indicated it was not resistant to the corrosive properties of the K.

Results of Spin Relaxation Measurements

The results of the measurements using these various coatings can be seen in table 1. The entry for stainless steel is used as our standard since it

has essentially no reflecting ability and the polarization is lost on each wall bounce. As a further test of the spin-relaxation measurement technique, an Ar buffer gas was added to an uncoated stainless steel cell in order to buffer the K atoms from the walls. A corresponding rise in spin-relaxation time was observed as shown in Table 1. The aluminum which has an anodized surface also has a relatively poor reflecting ability. This indicates that the coating may have considerable porosity and its ability to resist the corrosive action of the K may be poor. The most recent cell tested was that using Cu as a base; the results are very encouraging as can be seen from the table. It is apparent that we have a very good, solid coating with very little corrosion as this cell was used for approximately seven days with no sign of deterioration. The coating is suitable for use in the system.

Future Cells

In the future the plans include replacing the stainless steel cell with a pyrex system since it has several advantages. The drifilm produces a very good film within about 15 minutes and a simple NMR system can be employed to measure both the K and D polarization in the mixing cell. Furthermore, with this type of cell it should be easier to make the total system vacuum tight.

Acknowledgements

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References

1) R. J. Holt, M. S. Green, L. Young, R. S. Kowalczyk, D. F. Geesaman, B. Zeidman, L. S. Goodman and J. Napolitano, Nucl. Phys. A 446 (1985) 389C-392C.

2) R. J. Holt, Proceedings of CEBAF 1984 Summer Workshop, Newport News, VA 23606 (1984) p. 334.

3) R. J. Holt, Proceedings of the Workshop on Polarized Targets in Storage Rings, Argonne National Laboratory, Argonne, IL (1984) p. 103.

4) R. J. Holt, Proceedings of CEBAF 1985 Summer Workshop, Newport News, VA 23606 (1985) p. 45.

5) Proposal for a CW Upgrade for a Pulse Stretcher Ring at the William H. Bates Linear Accelerator Center, MIT (1986).

6) M. C. Green, Proceedings of the Workshop on Polarized Targets in Storage Rings, Argonne National Laboratory, Argonne, IL (1984) p. 307.

7) M. Green, Conference on Nuclear Physics will Stored, Cooled Beams, AIP No. 128, (1984) p. 268.

8) W. E. King et al., Phys. Rev. 97, 456 (1955).

9) G. Ohlsen, Rep. Prog. Phys. 35, 717 (1972).

10) M. D. Barker et al., Proceedings of the Fifth International Symposium on Polarization Phenomena in Nuclear Physics, AIP, 931 (1981).

11) DuPont TEFLON Coating fact sheet, DuPont Company, F & F Dept. Wilmington, DE 19898.

12) Drifilm

50% Sol A-(Dimethyl dimethoxysilane $(C H_3)_2 Si(OCH_3)_2$,

50% Sol B-(Trimethylmethoxysilane $(CH_3)_3 SiOCH_3$,

Acetic Acid (4 drops per 100 ml. solution)

13) L. W. Anderson and D. Swenson, private communication (1986).

14) SC-77

60% Dimethyldillowsilane $(CH_3)_2SiCl_2$

40% Trimethylchlorosilane $(CH_3)_3 SiCl$

Table 1. Observed spin relaxation times. $T_R(\mu s)$ represents the spin relaxation times for various K mixing cells tested.

SURFACE CONDITION	T_R (μs)
Stainless Steel	6
Stainless Steel + Ar Buffer	65
Drifilm on Al_2O_3	140
"Drifilm" on Cu	>1100
	>1300

Figure Captions

Fig. 1. Schematic diagram of the system used to obtain polarized deuterium atoms.

Fig. 2. Drawing of the metal mixing cell used to obtain polarized deuterium atoms.

SCHEMATIC DIAGRAM OF APPARATUS TO MEASURE TARGET POLARIZATION

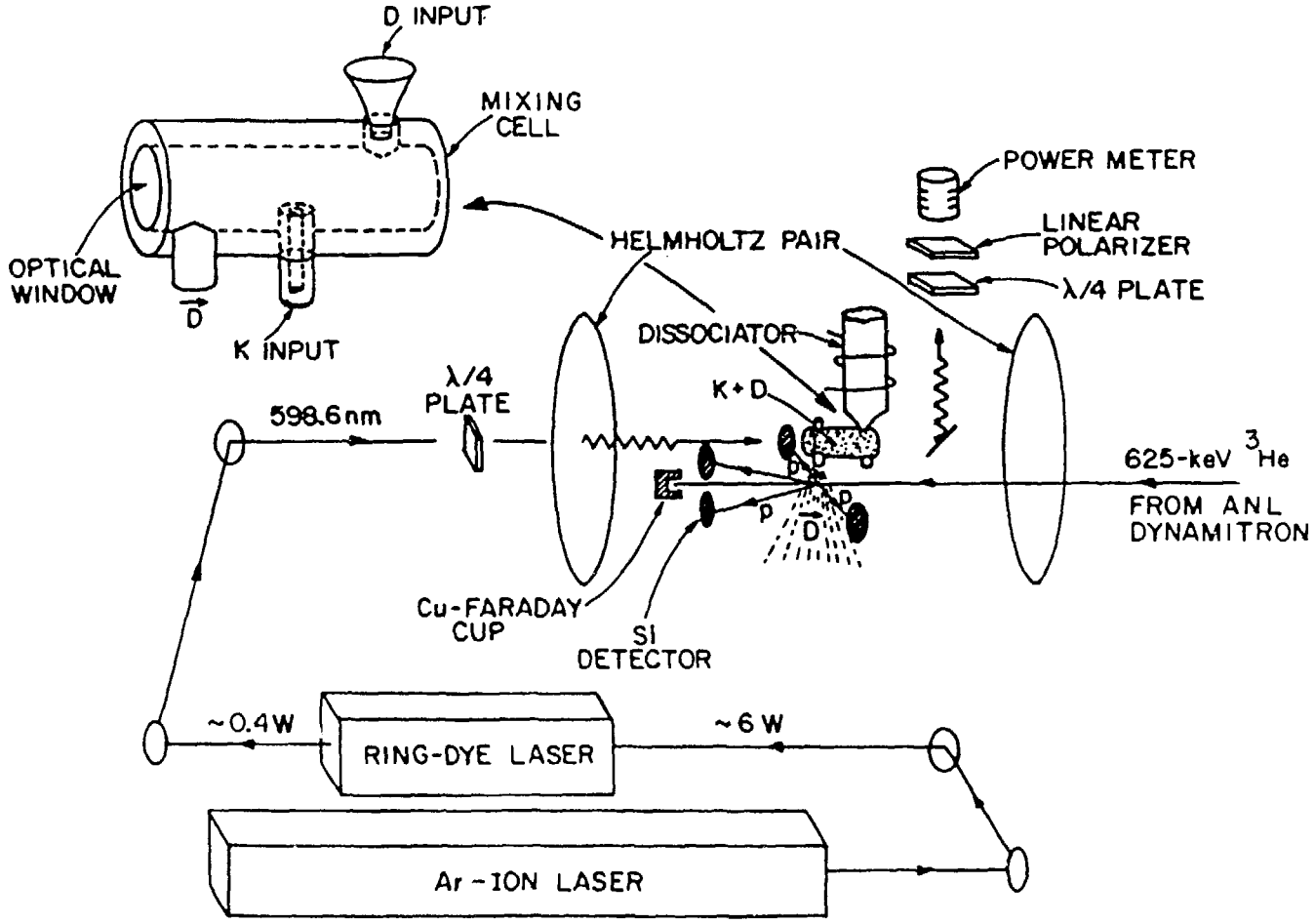

Fig. 1

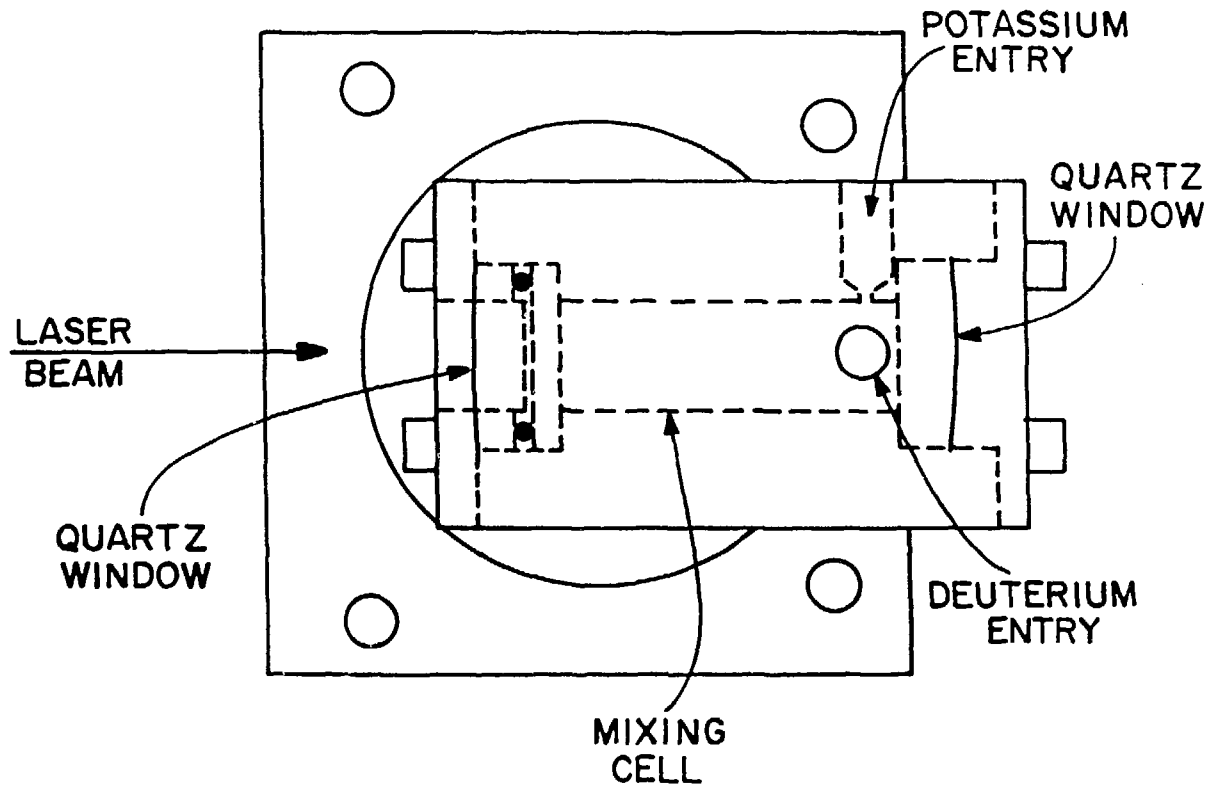
POTASSIUM
ENTRY
QUARTZ
WINDOW
LASER
BEAM
QUARTZ
WINDOW
DEUTERIUM
ENTRY
MIXING
CELL

Fig. 2

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