

Polarized Solid State Target

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Abstract. The polarized solid state target is an indispensable experimental tool to study single and double polarization observables at low intensity particle beams like tagged photons. It was one of the major components of the Crystal-Barrel experiment at ELSA. Besides the operation of the 'CB frozen spin target' within the experimental program of the Crystal-Barrel collaboration both collaborative groups of the D1 project, the polarized target group of the Ruhr Universität Bochum and the Bonn polarized target group, have made significant developments in the field of polarized targets within the CRC16. The Bonn polarized target group has focused its work on the development of technically challenging polarized solid target systems towards the so called '4e continuous mode polarized target' to operate them in combination with 4e-particle detection systems. In parallel, the Bochum group has developed various highly polarized deuterated target materials and high precision NMR-systems, in the meantime used for polarization experiments at CERN, JLAB and MAMI, too.

1 Introduction

Within the recent decades polarized solid targets as well as polarized particle beams evolved into indispensable tools in order to explore the spin structure of the proton and the neutron. Single and double polarization measurements were performed with a variety of different particles beams, among them not only experiments with polarized electrons and real photons. Protons, antiprotons and even polarized muons have been used so far at various laboratories [1]. (Double) polarization experiments at ELSA [2, 3] with tagged photon beam fluxes in the order of some megahertz have to rely on polarized solid targets with high target densities in order to provide sufficient luminosities of the particle reactions of interest. The developments of the polarized targets for particle physics experiments at ELSA within the CRC16 were twofold. On the one side we focussed on the enhancement of the figure of merit (FOM), which is defined as the product of the number n_t of target particles per cm^3 , the squared target polarization P_t^2 and the squared ratio f^2 of the number of polarizable nucleons and the total number of nucleons in the target. Improvements in P_t and f are directly related to the search and preparation of suitable target materials and need a detailed understanding of the dynamic nuclear polarization (DNP), as given by the spin temperature theory (for an overview we refer to [1] and for deeper studies see [4]).

On the other hand we worked on a significant enhancement of the luminosity L and angular acceptance $\Delta\Omega$ of the polarized target beyond the standard 'frozen spin technique'

towards the so called 'large angular continuous mode target' or '4e continuous mode polarized target'. The goal is to enhance the reaction counting rate N , which is defined as $N = L \cdot d\sigma/d\Omega \cdot \Delta\Omega$, and thus to improve considerably upcoming polarization experiments. The new scheme led to challenging and outstanding developments in cryogenics and superconducting magnet technology in the field of polarized solid state targets.

Besides the developments of new polarized target components and materials we operated the existing 'CB frozen spin target' (former 'GDH frozen spin target') as a major component of the Crystal Barrel experiment at ELSA for (double) polarization experiments.

Over the period of the CRC the goals and methods of the Bochum polarized target group focused on intense research on polarized target materials and their polarization behavior and the design and construction of more accurate as well as sensitive polarization measurement equipment. The broad spectrum of research covered the following topics:

- construction of a 'top-loading' ⁴He refrigerator for target material research
- pulsed and CW NMR for polarization measurements [5, 6]
- polyethylene and other oxygen-free hydrocarbons (alkanes) as polarized target materials
- radiation resistance of target materials with spinless spectator nuclei for high intense particle beam experiments

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Solid State On Target Publication

Wolfgang Beckmann



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containing heavy atoms meaningful Vector processing and more recently parallel processing techniques are playing an increasingly vital role in rendering the algorithms which arise in relativistic studies tractable This has been exemplified in atomic structure theory where the dominant role of the central nuclear charge simplifies the problem enough to permit some prediction to be made with high precision especially for the highly ionized atoms of importance in plasma physics and in laser confinement studies Today s sophisticated physical models of the atom derived from quantum electrodynamics would be intractable without recourse to modern computational machinery Relativistic atomic structure calculations have a history dating from the early attempts of Swirls in the mid 1930 s but continue to provide one of the primary test beds of modern theoretical physics

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a process abundantly used in the industry Crystallization can occur from a solution from the melt or via deposition of material from the gas phase desublimation Crystals distinguish themselves from liquids gases and amorphous substances by the long range order of its building blocks that entail the crystals to be formed of well defined faces and give rise to a large number of properties of the solid Crystallization is used at some stage in nearly all process industries as a method of production purification or recovery of solid materials Crystallization is practiced on all scales from the isolation of the first milligrams of a newly synthesized substance in the research laboratory to isolating products on the multi million tonne scale in industry The book describes the breadth of crystallization operations from isolation from a reaction broth to purification and finally to tailoring product properties In the first section of the book the basic mechanisms nucleation growth attrition and agglomeration are introduced It ensures an understanding of supersaturation the driving force of crystallization Furthermore the solubility of the substance and its dependences on process conditions and the various techniques of crystallization and their possibilities and limitations are discussed Last but not least the first part includes an intensive treatment of polymorphism The second part builds on the basics exploring how crystallization processes can be developed either batch wise or continuous from solution or from the melt A discussion of the purification during crystallization serves as a link between the two sections where practical aspects and an insight using theoretical concepts are combined Mixing and its influence on the crystallization as well as the mutual interference of downstream processes with the crystallization are also treated Finally techniques to characterize the crop are discussed The third part of the book is dedicated to accounts of actual developments and of carried out crystallizations Typical pitfalls and strategies to avoid these as well as the design of robust processes are presented

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