SOURCE OF POLARIZED ELECTRONS

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Abstract:

A source of polarized electrons based on photoemission of GaAsP-cathodes has been set up at the Mainz 300 MeV linear accelerator. It was successfully run in a measurement of parity violation in quasielastic electron beryllium scattering at 300 MeV and backwards angles. The source parameters are: Degree of polarization P=0.44, average beam current I =28 μA, peak current I_p=140 mA, life time of cathode 200 h. A c.w. source for the Mainz race track microtron MAMI is designed using the same basic photoemission process and will be built up in 1988.

Introduction

The cross section in electron nucleon scattering depends on electron helicity because of weak forces in electron nucleon interaction /1,2,3,4/. To reveal this parity violating part of interaction one may measure the "analysing power" for longitudinally polarized electrons of an electron-nucleon-collision process. This has been done the first time at SLAC in several celebrated experiments on deep inelastic scattering of polarized electrons from deuterium at collision energies around 20 GeV /5/. A similar investigation has been performed at the linear accelerator in Mainz now, in which the analysing power for longitudinally polarized electrons in quasielastic scattering from beryllium was measured at a collision energy of 300 MeV /6,7,8,9,10,11/. The present work describes the source of polarized electrons that was successfully run in the beryllium parity experiment.

A source of basically similar design is developed for the race track microtron MAMI in Mainz at present.

Source of polarized electrons at the 300 MeV linear accelerator in Mainz.

The source is based on photoemission of a $GaAs_{0.62}P_{0.38}$-cathode activated to negative electron affinity. In case of inradiation with circularly polarized light of a frequency just above absorption threshold such a crystal emits electrons with spin orientation that is antiparallel to the photon spin preferentially /12,13,14,15,16/. Fig. 1 sketches an overall view of the source assembly, Fig. 2 shows some details of its gun.

The light source is a flashlamp pumped dye laser working at 644 nm with a repetition frequency of 50 Hz /17/. Circular light polarization is achieved with the help of a Glan prism followed by a pockels cell used in quarter wavelength retardation mode. The helicity of the photons may be reversed by reversing the sign of the voltage applied to the pockels cell; by that way the sign of spin-polarization of the electrons emitted may be changed. The half wave plate following the Glan prism is introduced for doing cross checks: 90°-rotation of the plane of linear polarization of the light leaving the Glan prism reverses the correlation in between helicity of the light shining upon the cathode and the sign of pockels cell voltage, 45°-rotation produces linearly polarized light at the cathode which results in emission of unpolarized electrons. The modulator consists of a transverse pockels cell essentially. It is used to shape the light pulses. Flat topped pulses of 4 μs duration are necessary to match the hf-characteristics of the linear accelerator.

The electrons leaving the cathode are accelerated to 44 keV and transmitted to the entrance of the accelerator by a beam line consisting essentially of two magnetic dipols and two solenoids. The polarization of the electrons

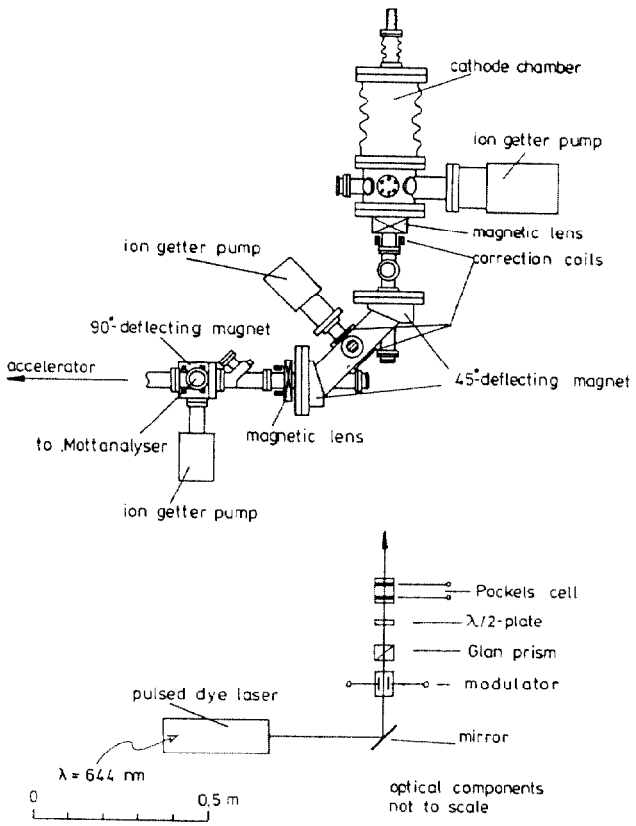

Fig.1: Source of polarized electrons set up at 300 MeV linear accelerator in Mainz.

may be analysed by deflecting the beam towards a side arm (not shown in fig. 1) comprising a Wien filter and a Mott analyser. All parts of the source are compatible with ultrahigh vacuum requirements. A risidual gas pressure in the low 10^{-10}mb range is crucial for a good life time of the cathode.

Besides minor differences in the cathode-anode distance and the use of a different type of III-V-semiconductor-cathode the electron gun of fig. 2 is a copy of the SLAC design used in the Stanford parity experiments /5,16/. It is necessary to have a cathode surface with negative electron affinity (NEA) in order to get electron emission at photoabsorption threshold. NEA-preparation is done in situ by bringing a layer of cesium and oxygen or cesium and fluorine /16/ upon the clean cathode surface.

The source was successfully run in several one week beam times at the linear accelerator in Mainz. In summary its parameters are:

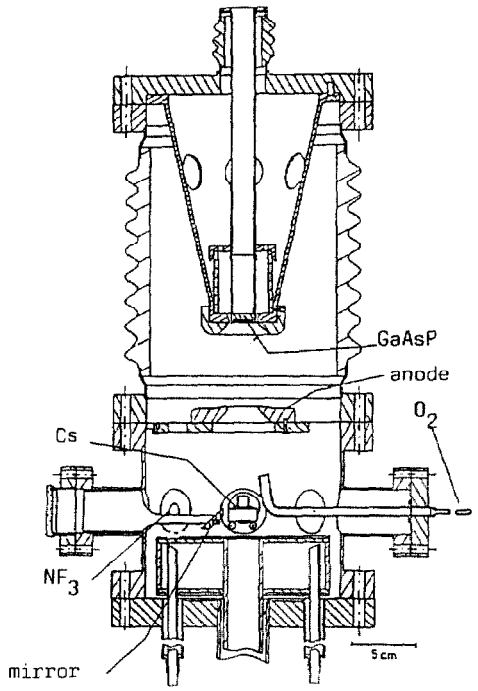

Fig.2: Gun of polarized electron source.

Cs = cesium dispenser cathode
O_2 = oxygen inlet via Ag-tubing
NF_3 = NF_3-inlet via valve

peak current	140 mA
pulse width	4 µs
pulse repetition	50 Hz
mean current	28 µA
spin polarization	0,44
life time (decrease of quantum efficiency to 1/e of starting value)	200 h

Source of polarized electrons at MAMI.

Following the design of the above presented source of the Mainz linear accelerator a new source is being built for the race track microtron MAMI. The gun optics had to be redesigned to meet the more stringent conditions that are put on the beam phase space by the injector LINAC of the microtron. A spin manipulator is being developed that will be inserted in between source and injector. Its purpose is to compensate for spinprecession within the microtron.

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