THE POLARIZED ATOMIC BEAM SOURCE FOR THE ANKE-SPECTROMETER

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At the beginning of 1998 the magnet spectrometer ANKE was installed into the COSY ring (FZ Jülich, Germany) and unpolarized measurements on meson production started. Future experiments will make use of the polarized COSY-proton beam and the polarized hydrogen and deuterium internal storage cell gas target. The present report describes the recent progress in establishing and testing the polarized atomic beam source (ABS) and based on the previous PNPI research report 1996-1997 [1] and IKP Annual Report 1998 [2].

The rf dissociator

The dissociator is completely assembled and has been tested in long-term operations. A Hüttinger 13.6 MHz 600 W rf generator [3] with a match box is used to power the plasma. MKS flow controllers [4] are installed allowing primary H_2 or D_2 inlet flows up to 8.5 $mbar\cdot l\cdot s^{-1}$ and O_2 admixture up to 0.2 $mbar\cdot l\cdot s^{-1}$. The pressure in the dissociator gas volume is measured by an MKS Baratron gauge. These units are controlled via a fieldbus (PROFIBUS DP) by a PC based WinCC system running under Windows NT [5]. The ABS beam has been studied for H_2 inlet flows up to 5 $mbar\cdot l\cdot s^{-1}$. Preliminary measurements of the degree of dissociation in the beam have been carried out with O_2 admixtures of the order of 0.1 atomic %.

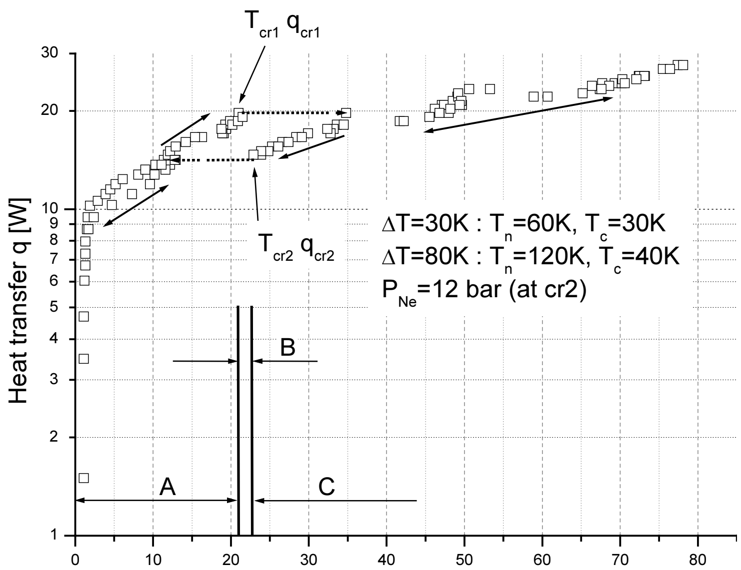

Fig. 1. Relation between the heat transfer and the temperature difference ΔT between nozzle (T_n) and cold head (T_c) measured with the ABS Ne heat pipe (6.2 cm^2 lower, boiling surface).

The nozzle-cooling system

The first basic tests of the setup have been performed with a Cu heat bridge connecting the cryocooler (Leybold RGS 120 [5]) and the nozzle to be cooled down to temperatures 60 to 120 K at a heating power by recombination of atoms around 10 W. Due to its appreciably smaller mass, a Ne heat pipe should allow much faster nozzle-temperature variations [7,8], e.g. for heating up to clean the nozzle. Thus, after the first successful studies the Cu heat bridge has been replaced by a cryogenic Ne heat pipe. As an example of the first measurements Fig. 1 shows the relation between the transferred heat and the temperature difference between the nozzle and the cold head of the cryocooler. The three regions A, B, and C correspond to bubble, transitional column, and surface-film (Leidenfrost) boiling, respectively. The measured curves also show the expected hysteresis-loop behaviour. The values ΔT_{cr2}=23 K and q_{cr2}=23 W, measured at 12 bar Ne gas pressure, agree very well with the calculated values of 26 K and 25 W, respectively.

Table 1: The calculated and measured pole tip field strengths of the sextupole magnets (dimensions in mm).

Magnet	d_{inner}	d_{outer}	l	B_0^{calc}[T]	B_0^{meas}[T]
1	10/14[a]	40	40	1.633	1.634(8)
2	16/22[a]	65	65	1.641	1.684(6)
3	28	94	70	1.642	1.625(4)
4	30	94	38	1.564	1.565(2)
5,6[b]	30	94	55	1.605	1.621(3)

[a] magnet with conical aperture
[b] both magnets have identical dimensions, only the field distribution of magnet 5 has been studied in full detail

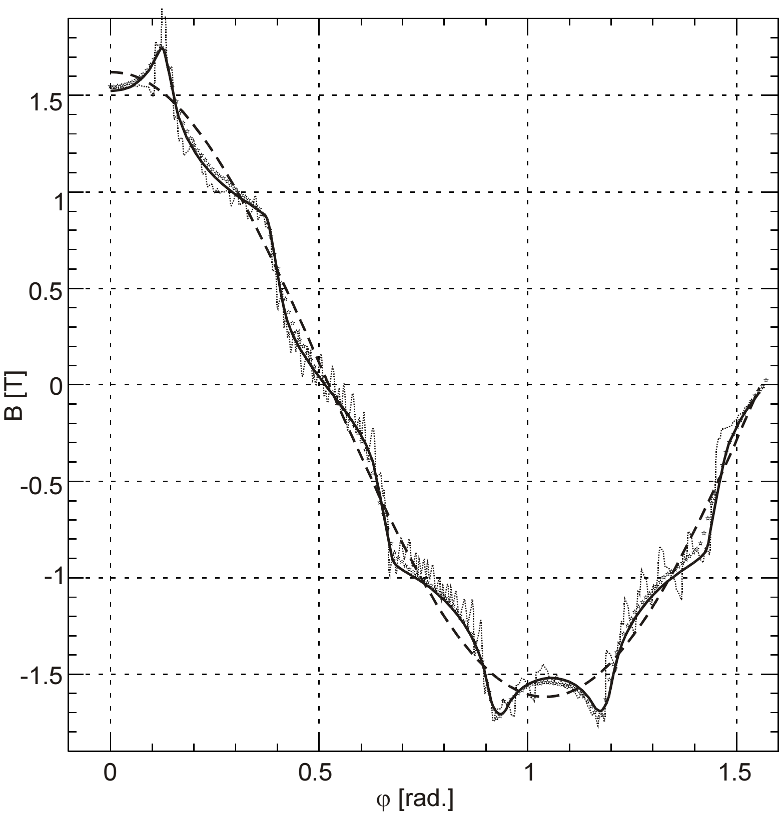

Fig. 2. Azimuthal field distribution, measured at 0.1 mm distance from the aperture surface of magnet 5 (stars), in comparison with that from the MAFIA calculation (dot line), the fit by the Halbach formula [11] with B_0 as free parameter (solid line), and the pure 6-pole distribution (dashed line).

The permanent sextupole magnets

The six permanent NdFeB sextupole magnets have been delivered by Vakuumschmelze [9]. Assembled from 24 segments, made from 3 materials differing in remanence and coercivity (VACODYM 510HR, 383HR, 400HR), they yield the pole tip field strengths listed in table 1, which are in excellent agreement with the predictions of MAFIA field calculations. Careful studies of the field distribution have been performed with a small Hall probe [10] of 200x100 μm area and 15 μm thickness. The azimuthal distributions, measured near to the aperture surface, reveal 54- and 102-pole contributions superimposed on the basic 6-pole distribution. This behaviour is due to the 24-segment structure and is in agreement with the analytic predictions by Halbach [11] and the MAFIA calculations. An example of the measured distributions is shown in Fig. 2. Laser welding of the stainless-steel encapsulation is in progress [12]. The magnets will be installed in the beginning of 2000. A publication on the results achieved is in preparation.

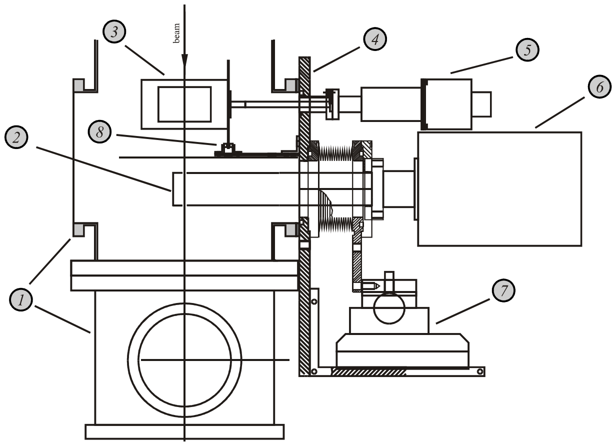

Fig. 3. Sideview of the QMS device: ABS chamber (1), crossed beam QMS (2), cylindrical chopper (3), sup-porting flange (4), rotary drive (5), preamplifier and HV supply (6), x-y table (7), LED support (8). The arrow indicates the direction of the atomic beam.

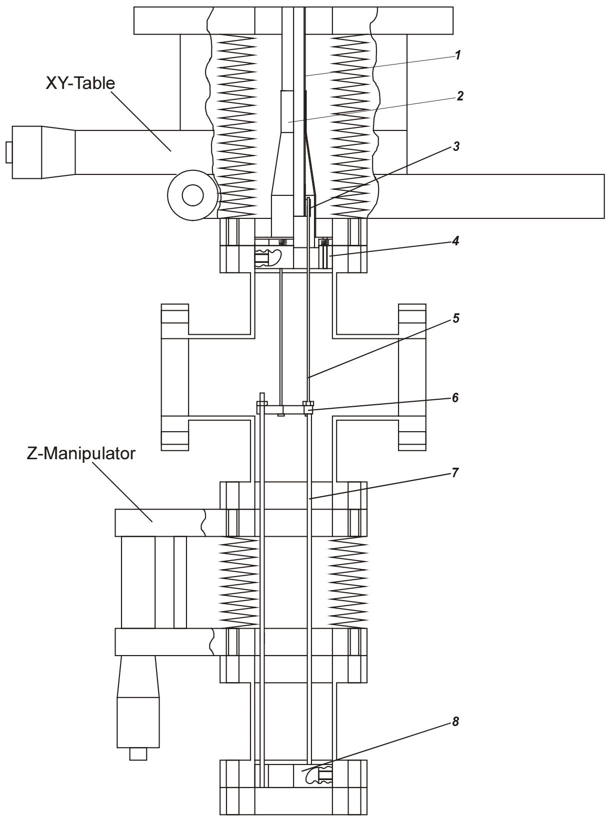

Fig. 4. The setup with the compression tube (1), its guidance tube (2), and support components (3 to 8). The two intermediate flanges are used to mount the hot cathode pressure gauge and the unpolarized calibration gas inlet, respectively.

The degree-of-dissociation measurements

The device for the measurements of the degree of dissociation with a crossed - beam quadrupole mass spectrometer (QMS) has been installed and tested [13,14]. As shown in Fig. 3, it is mounted on a two-dimensional manipulator, which facilitates to measure the degree of dissociation of the beam and also to determine the beam profile.

The rf-transition units

The weak and medium field hyperfine transition units for hydrogen have been designed and manufactured [15]. The medium field unit has been installed. In order to test its proper functioning, the homogeneous magnetic field strengths at a series of field-producing currents have been determined by tuning the rf frequency to the maximum of polarization measured with the QMS. The field strengths, deduced from the resonance frequencies and the theoretical hyperfine splitting, are in good agreement with the values measured using a Hall probe [16]. Furthermore, the polarization has been studied as a function of the applied rf power.

The device for beam-intensity studies

These measurements will be carried out using a compression tube. The device has been built and installed [17,18] with the compression tube placed at the same location as the feeding tube of the storage cell (300 mm from the exit of the last magnet). Absolute beam intensities and distributions will be measured using a combination of x-y and z manipulators (Fig.4) after installation of the magnets and rf-transition units. A special calibrated unpolarized gas feed system will permit to measure the absolute beam intensity with an accuracy of a few percent. It also may be used to feed a storage cell for first measurements with unpolarized gas.

Beam-profile measurements

A two-dimensional monitor of the atomic flow has been developed [18] based on the recombination heat transferred to the surface of thin tungsten wires. A prototype with 8x8 wires has been used to prove the applicability of the method [19].

The slow control system

The slow control system is based [4] on the consistent use of industrial technologies like SCADA (Supervisory Control and Data Acquisition), fieldbus (PROFIBUS DP), and PLC (Siemens S7). To give an example for the performance achieved, the system enabled degree-of-dissociation studies under full automatic control. At present the system processes 200 signals to and from a variety of pumps, valves, measuring devices, rf generators and PID controllers.

PC controlled parameter studies

The ABS is controlled by WinCC software which provides UDP protocol service for remote operations. Special software was developed for data acquisition and ABS control from a remote Windows computer. It uses a protocol based on XDR and UDP to communicate with the WinCC program and acquires additional data from directly connected devices such as the QMS or the wire monitor [20]. This software provides automatic measurements with the ABS.

Beam polarimetry

The first measurement of beam polarization has been performed in a temporary setup. Two magnets with the dimensions of magnet 1 (table 1) with pole tip fields of about 1.15 Tesla were installed before and behind the medium field transition unit. The polarization of about 28%, measured with the QMS, agrees with the prediction of trajectory calculations. It is planned in the future to use the Lamb-shift polarimeter which is under construction at the Universität zu Köln [21].

In 2000 the ABS will be competed and the beam optimization measurements will be done.

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