ADAPTION OF A PARTIALLY HEATED PUMPING CELL WITHIN A MOBILE ^{129}XE POLARIZER: FIRST RESULTS AND ISSUES

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Purpose

For measurements at MR scanners and imagers at various sites a compact self-sustained ^{129}Xe polarizer was set up which can be easily transported and put into operation [1]. The concept of a partially heated spin exchange optical pumping (SEOP) cell [2] was used in this setup. Nevertheless, as our aim was a very compact polarizer, we retained a relatively small, horizontally arranged SEOP cell. Although various ^{129}Xe polarizer have been described in literature our approach shows features not yet discussed.

Methods

The polarizer is housed in an aluminum rack measuring 130 × 64 × 152 cm³ (W × D × H) as shown in Fig. 1. All supply elements are arranged underneath the optical pumping chamber (enclosed in black aluminum walls). The blueprint on top of Fig. 1 shows the containment of the SEOP glass cell (21 cm long, 4.2 cm OD). The side with the gas inlet arm is housed within the oven heated by hot air. At this side some droplets of rubidium were deposited in the pumping cell. Close to the gas exit arm an RF shield is surrounding the cell and the Tx/Rx-coil to suppress ambient noise for the online NMR measurements. Compressed air flow fed into the RF shield cools the glass cell almost to room temperature. This arrangement is intended to suppress the so called 'Rb runaway effect' [3] which we observe in a stationary ^{129}Xe polarizer with an all heated cell with same diameter but shorter length of 7 cm [4]. This avalanche like self-heating of the Rb vapor by absorption of laser-light above a critical temperature makes it difficult to control the cell temperature and to establish optimum heating conditions. The gas mixing system with three independent mass flow controllers allows for setting a wide range of partial pressures and total gas flow for the gas mixture of Xe, N_2 and He gas. The pumping laser is a spectrally narrowed high power laser diode (P_{max} = 75 W, $\Delta\lambda$ = 0.4 nm). In the beginning a 30 cm glass fiber was used to couple the laser to the collimator so that only 80 % of the laser power was passing the linear polarizing beam splitter cube (i.e. 20 % of power were lost) which is placed before the quarter-wave plate. A very short (5cm) glass fiber coupling the laser to the collimator maintains the linear polarization of the laser almost completely and only 2 % of the power is lost. An online NMR system allows for absolute ^{129}Xe polarization measurement using the coil inside the RF-shield as well as spatially resolved measurements along the cell with a second Tx/Rx coil inside the oven [1] (Fig. 1).

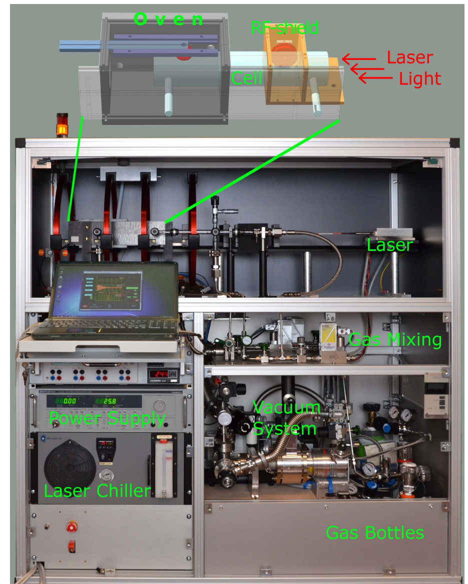

Figure 1: Image of the ^{129}Xe polarizer with sketch of optical pumping cell on top

Results

Initially with approximately 40 W of laser power at the entrance of the SEOP cell, ^{129}Xe polarization of P_{Xe} ~40 % in a batch mode without gas flow (p_{Xe} = 0.1 bar, p_{tot} = 3 bar) was achieved. For xenon flow at rates of Φ_{Xe} = 6.5 mln/min and Φ_{Xe} = 26 mln/min, P_{Xe} = 25 % and P_{Xe} = 13 % were achieved, respectively [1]. Already during this operation a decrease of transmitted laser power through the cold cell (i.e. without Rb vapor in the cell) was seen, from initially 35 W down to 30 W after two months of operation. With the 5 cm fiber 50 W of incident light power at the SEOP cell became available. The transmitted light power through the cold cell was not higher than 30 W, however. Furthermore, the deduced ^{129}Xe polarizations were a factor of two smaller than in the first month. Deliberate variation of the laser output showed, however, that this loss cannot be explained by insufficient light power (Fig. 2). With higher power a decrease of the optimum cell temperature of 10 °C is seen. For the batch mode no more than 5 % increase in polarization (21.5 %→22.4 %) is gained by the 25 % increase in incident laser power whereas for the flow modes an increase of about 15 % is gained (13.7 %→15.7 % and 6.1 %→6.9 %).

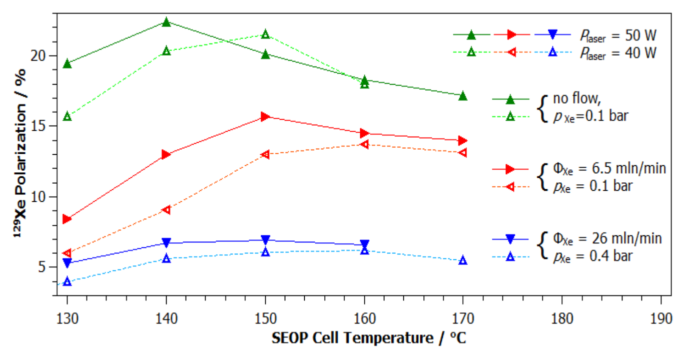

Figure 2: ^{129}Xe polarization for different laser power and flow conditions

Discussion and Conclusion

The decrease in transmitted laser power for the cold SEOP cell clearly indicates that the cell windows became more and more opaque due to rubidium precipitation. Especially on the cold side of the cell outside the oven this is apparent as a gray haze is seen very easily in the region where the RF shield is situated. The decrease in the measurable ^{129}Xe NMR signal and hence the deduced polarization levels is attributed to an RF shielding effect due to this Rb metal layer in between the NMR coil outside and the xenon gas inside the cell.

With a clean glass cell the setup shows very good operation and the adaption of a partially heated pumping cell to a relatively small cell dimension helps to minimize the effect of Rb runaway. Further improvements are needed, however, with respect to where the Rb condensation inside the SEOP cell takes place. A separate heating of the cell window where the laser light is entering seems to be mandatory and Rb condensation near the RF coil for the online NMR measurements must be avoided.

References

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