Design of the optical setup for hyperpolarized ^{129}Xe

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Abstract— **An original installation is presented for production of hyperpolarised xenon by optical pumping. It is shown that an efficient technology may be implemented with an average-power pump laser (20–30 W) having a line width of 0.1 nm in the vicinity of a Rb absorption line. The excess of the spin polarisation within the gas over the equilibrium value may be up to three orders of magnitude.**

Keywords— hyperpolarized Xe-129; nuclear magnetic resonance; spin-exchange optical pumping

I. Introduction

Hyperpolarized (HP) ^{129}Xe can be used to significantly raise the sensitivity of nuclear magnetic resonance (NMR) methods in various fields including medicine and characterisation of porous materials. Spin-exchange optical pumping is one of the efficient methods for preparation of HP ^{129}Xe. This method is relatively long-established [1]. However, because of the continued progress in lasers and components, the apparatus for preparation of HP ^{129}Xe undergoes modifications that may lead to better solutions. In addition, the limited lifetime of HP ^{129}Xe (tens of minutes) necessitates development of better local means of HP ^{129}Xe production on the basis of accessible elements. The present work proposes a design of the optical setup for HP ^{129}Xe production implemented on the modern technology level and able to produce gas samples of about 0.2 – 0.4 l in volume with the degree of nuclear spin polarisation exceeding the equilibrium by three orders of magnitude and more.

Fig. 1 shows a schematic diagram of the laboratory set-up for production of HP ^{129}Xe. The installation includes a diode pump laser DLW-795 by “Photonics Laboratories”, optical components by Thorlabs, self-fabricated optical cell with a 200-ml volume and a self-made solenoid.

It must be noted that even though the technology is relatively old, not all the necessary components for it are yet available commercially and some have to be fabricated in house. First of all, this is the optical cell where spin-exchange action is performed under optical pumping, and also the magnetic coils needed for maintenance of spin polarisation in the experiment and during transportation of the prepared samples.

This report provides details of the developed experimental installation, its parameters, and recommendations on how to fabricate the necessary components. Also discussed are the approaches to scaling of similar equipment. An analysis is offered of the bottlenecks of this technology.

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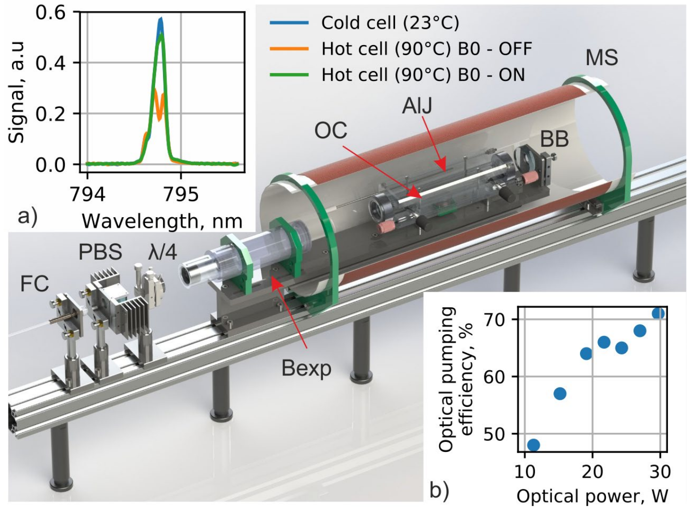

Fig. 1. Experimental installation for production of hyperpolarised ^{129}Xe. FC – fiber collimator, PBS – polarizing beam splitter, λ/4 – waveplate, BExp – 3 lens telescopic beam expander, OC – optical cell with optically grade windows, AlJ – aluminum jacket with liquid heating/cooling, BB – beam block/reflector, MS – three-coil magnetic solenoid. Diode laser, gas system, MS current driver are not presented on the scheme. Insets a) spectra of radiation transmitted through the cell, b) dependence of the efficiency of optical pumping on the laser power for cell with 2 atm of $Xe:N_2/1:1$ (efficiency is defined as the degree of rubidium atoms polarisation).

II. Conclusiion

An original installation has been created for production of hyperpolarised ^{129}Xe by optical method. A description is given of the components of the installation that need to be fabricated in house. Results of commercial component testing are provided. The principles of development of such equipment are discussed, as well as their influence on the development of NMR techniques [2]. Possible ways are proposed for the further development of equipment for spin hyperpolarisation of noble gases.

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