# $^{129}$Xe Polarizer Commercial Prototype

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**Introduction**

Hyperpolarized $^{129}$Xe may be used as a contrast agent for pulmonary functional imaging (1) and for imaging of very small molecular concentrations not previously achievable with MRI (2). The lack of large volumes of highly polarized $^{129}$Xe presents an obstacle to faster progress in the field (3). We present progress towards a commercial prototype $^{129}$Xe polarizer suitable for deployment in hospitals and universities.

**Polarization**

The centerpiece of the design is a spin-exchange optical pumping (SEOP) chamber made of glass into xenon and a mixture of buffer gases is added. A high-power circularly polarized laser polarizes the xenon via Rb-Xe collisions. This continuous flow polarizer produces magnetization output that significantly exceeds the previously published best $^{129}$Xe polarizer (4). Production was 55.8% at 0.96 sL/Hr and 42.9% at 1.92 sL/Hr. An increase in laser power and decrease in operating pressure optimized polarization (figure 1).

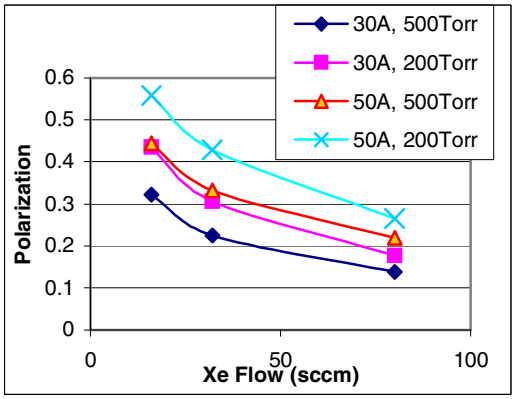


Figure 1: Polarization vs. Xenon Flow Rate

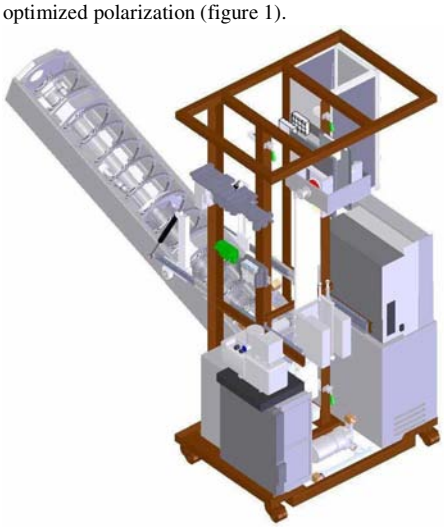

Figure 2: Compact Polarizer with SEOP chamber tilted out for servicing.

Laser Technology

We are using spectrally narrowed external-cavity laser diode arrays to optically pump the Rb vapor in the SEOP chamber (figure 2). Currently, the polarizer uses a 9 bar, 100-200 Watt spectrally narrowed laser. Polarization is expected to increase with the use of a new, more powerful laser. Construction of the 12 bar, 1.1kWatt spectrally narrowed laser is complete. Figures 3a and 3b show the spectrum for the twelve individual lasers and the overall spectrum. Bar-bar misalignment on the diode stack assembly spreads out the overall spectrum and causes some diodes to produce light that is outside the Rb absorption spectrum. The new laser produces 1.1kWatt of spectrally narrowed light with a width of 0.4nm.

Serviceability

Advancements in automation and serviceability include a tilting mechanism for removal of the SEOP chamber and computer control of glass stopcocks, metal valves, gas mixing, chamber pressure, temperature, and laser power. While employing Quality System Consultation, we are building a Xenon polarizer using a controlled specification.

Freeze-out

An automated xenon freeze-out system consists of a computer controlled quartz cryostat that is submersed in liquid nitrogen for 129Xe accumulation or hot water for sublimation. A fast sublimation mechanism is important since the polarization relaxation time T1 is short for frozen xenon close to the melting point. Utilizing linear actuators and stepper motors, the computer removes the liquid nitrogen and thaws the frozen xenon in under 6 seconds.

**Polarimeter**

The polarizer has an onboard, permanent magnet 1-D NMR setup for polarimetry. The system is controlled by an inexpensive LabVIEW-controlled desktop computer and uses proton NMR at 8mT for calibration.

**Outlook**

The construction of the polarizer under a controlled specification allows us to easily move towards a polarizer that may pass FDA regulatory controls. The next year will bring more big changes as we implement a polarizer with a Xenon flow rate of 120 sL/Hr using a recently completed gas flow system. Success in these areas are an invitation to collaboration with clinicians interested in the potential of Hyperpolarized Xenon.

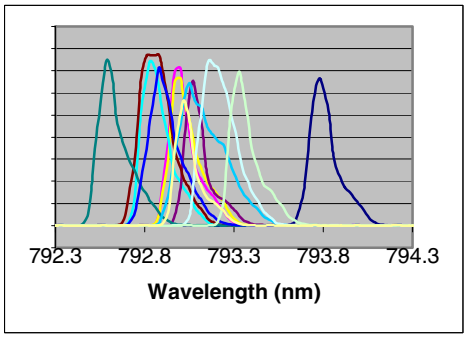


Figure 3a: Individual 12 bar 1.1kWatt laser intensity.

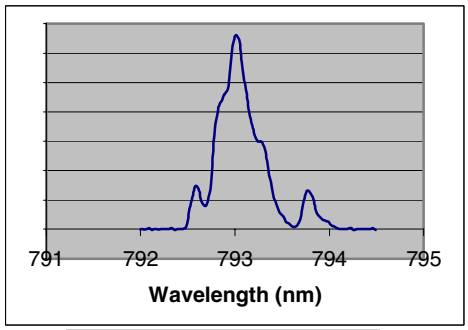


Figure 3b: Total Laser Intensity (arb. units)

This work is supported by NIH under STTR contract RR20200.

References

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