Hyperpolarized Helium-3 gas Production and Delivery for use in Lungs of Pediatric Subjects

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Lung disease is a major cause of morbidity in children. Spirometry and computed tomography (CT) are currently the common techniques to diagnose pediatric lung disease. However, young children cannot perform forced breathing maneuvers and CT only provides indirect information of the lungs. In addition, CT provides a relatively high dose of ionizing radiation. Hyperpolarized helium-3 has emerged as an extremely viable option for imaging pulmonary functional microstructure. The Apparent Diffusion Coefficient (ADC) can quantify the extent of alveolarization, determine the stage of prematurity, and/or assess injury to septal walls associated with chronic lung disease or prematurity. Polarized 3He MRI can provide medical professionals with information about pediatric lung structure that is essential to selecting the best course of treatment.

In order to successfully obtain pediatric lungs images, infrastructure needed includes a 3He polarizer, transportation case and cell, administration method, fast imaging sequences (spiral), and a way of analyzing of images. We have implemented an HSEOP 3He polarizer (Z3, Figure 1) capable of using an 8.5L pumping cell. It is designed to equalize pressure inside and outside of the glass polarization vessel and has the ability to dispense polarized gas into external vessels. We have also explored and tested the other parts of the infrastructure needed for a successful lung image, which will be discussed in the presentation.

Glass cell development is also a large part of our group's work. We have tested glass cells of varying materials, shapes, and volumes. Our polarizer design allows for us to test these cells in an external environment before using them to transport gas or installing them in a polarizer (Figure 2). We not only have studied the cells themselves, but also techniques for preparing them (rinsing, baking out, etc). Our efforts have lead to some promising results. A few small (0.5L - 1.5L) spherical cells intended for transportation of gas have achieved T1 lifetimes of up to 65 hours. An 8.5L pumping cell, coated with a sol gel adapted from Hsu's procedure¹, achieved a lifetime of 30 hours externally. And a smaller, 2L potential polarizing cell had a T1 of 70 hours. However, up to this point, external T1 results of these polarizing cells has not translated when installed in our polarizers. Current effort is directed at a better understanding of polarization loss mechanisms so that high external cell lifetimes translate into high polarization. Other issues encountered during polarization and transportation of gas will also be discussed in the talk.

Recently, we were able to send polarized gas from Durham, NH to Charlottesville, VA (UVA). There, our collaborators at UVA were able to take an MRI of the storage cell and verified that gas remained polarized during the shipment (Figure 3). This test showed the feasibility of providing polarized 3He to hospitals and we hope to soon extend this process to image pediatric lungs.

One way we look to accomplish this is with our new polarizer, Z4, that has become operational within the last three months. This new polarizer is equipped with an improved narrowed laser that will help optical pumping of the alkali. Also, an enhanced thermal design allows for greater control of the polarizing volume temperatures to help with spin exchange. Currently, tests are being run to find optimal operating conditions to give the highest possible polarization. These upgrades, combined with improved pumping cell performance and dispense techniques already developed, will hopefully enable our group to acquire pediatric lung images using polarized 3He with MRI.

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References:

Oral Presentation Preference