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Laser-polarized noble gases: a powerful probe for biology, medicine, and subatomic physics

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For over a decade, laser-polarized noble gases such as ^{3}He and ^{129}Xe have proven useful for a wide range of scientific inquiries. These include investigations of pulmonary disease using the polarized gas as a signal source for magnetic resonance imaging (MRI), measurements of various aspects of nucleon structure, and tests of fundamental symmetries. Early efforts were often limited by expensive and bulky laser systems, but ongoing advancements in solid-state lasers have enabled increasingly large volumes of polarized gas to be produced with steadily improved polarization. Equally important have been advances in the fundamental understanding of spin exchange. This has led, for example, to the introduction of hybrid mixtures of alkali metals that can increase the efficiency of spin exchange by an order of magnitude. As a consequence of these advances, the figure of merit for polarized nuclear targets has increased by roughly three orders of magnitude in comparison to early accelerator-based experiments. And in MRI applications, it has become possible to pursue increasingly sophisticated imaging protocols that provide a wide range of diagnostic information. Even the earliest noble-gas MR images of the gas space of the human lung provided unprecedented resolution. More recent work includes the use of diffusion-sensitizing pulse sequences to study lung microstructure, and tagging techniques that enable the visualization (in real-time MRI movies) of gas flow during breathing. The range of applications of laser-polarized noble gases is continuing to grow, and it is notable that with an improved understanding of the underlying physics, it is quite likely that the capabilities of this useful technology will expand for some time to come.