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In search for dark matter components, physicists edge closer by watching radiation shifts

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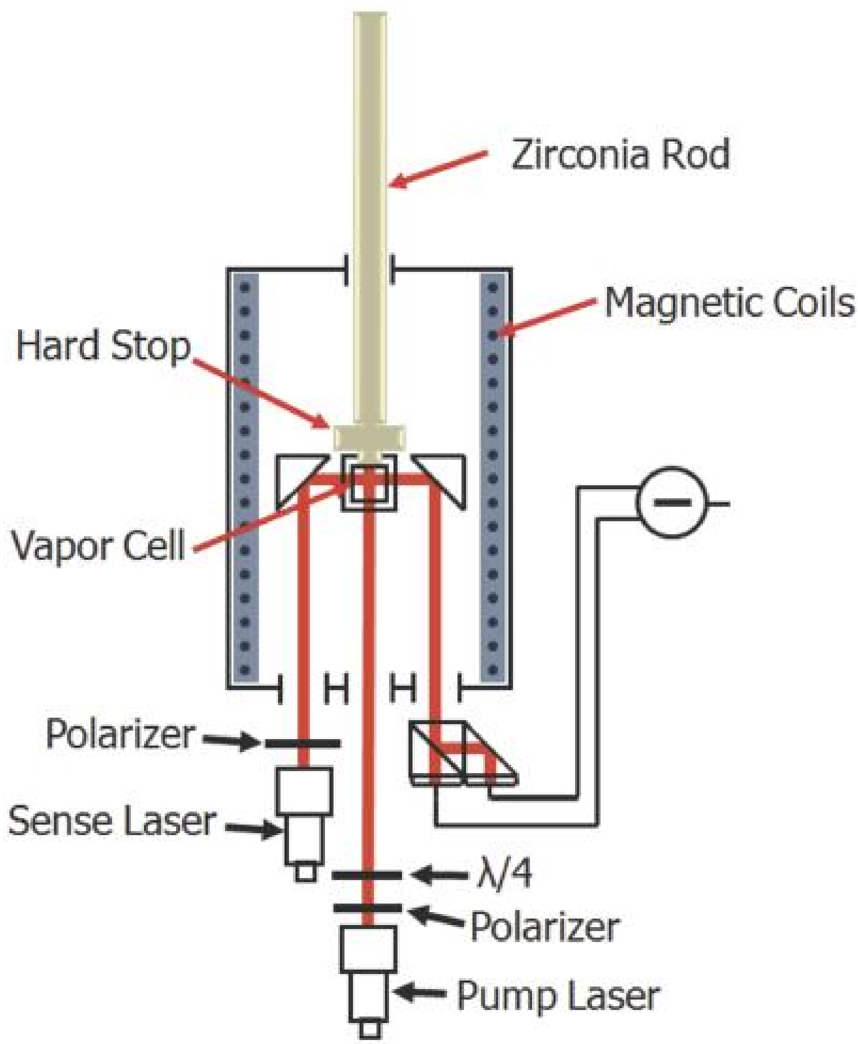

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(Phys.org) —Nuclear magnetic resonance—that phenomenon where nuclei of certain atoms, when in a magnetic field, take in and give off measurable amounts of electromagnetic radiation—is everywhere.

Indiana University Health Proton Therapy Center uses a type of it to visualize nuclei of atoms inside the human body, and chemists like IU's David Giedroc use nuclear magnetic resonance to determine protein structure. Its radio frequency range of between 40 and 50 megahertz is akin to that of short wave amateur radio. Even water, when you zoom in on the single proton found in the nuclei of its two hydrogen atoms, produces a measureable nuclear magnetic resonance signal.

Now, a team of physicists at IU Bloomington that has been hunting for nuclear magnetic resonance frequency shifts 100 billion times smaller as part of a search for new particles in nature that are very weakly coupled to matter, has never been closer to confirming whether the predicted particles do exist.

Led at IU by College of Arts and Sciences' Department of Physics professor W.M. Snow in collaboration with researchers at Northrop Grumman Corp. and the University of Wisconsin, the team this week announced a new set of nuclear magnetic resonance frequency shift measurements in two polarized isotopes of the noble gas xenon. The new results provide the highest level of sensitivity to date for the possible presence of exotic new particles with masses in the sub-electron volt range (less than the mass of a single neutron, proton or electron).

These new predicted particles—called WISPs, or weakly interacting sub-electron volt particles, by some theorists—include one particular hypothetical elementary particle called an axion that could be a component of dark matter or dark energy in the universe.

"If eventually found to be present, these axion particles would exert a force between a normal hunk of matter and spin-polarized matter in which the nuclei of the atoms are all set up to spin in the same direction, similar to the protons in your body used in magnetic resonance imaging," Snow said. "If present, the axion force would change the precession frequencies of the two xenon isotopes differently."

The experiment used a test apparatus for a new type of navigation system being developed by Northrop Grumman that employs spin-polarized nuclei—in this case the xenon isotopes 129Xe and 131Xe—as atomic-scale gyroscopes that always point in the same direction. Applications for use of the new navigation technology are likely to emphasize small size and low power requirements, including personal and unmanned vehicle navigation in GPS-denied and GPS-challenged locations.

The team's final results improved on the precision of the search by two orders of magnitude for WISP-induced forces with ranges near 1 millimeter, and Snow said they expect that the sensitivity of this technique can be increased by at least two more orders of magnitude. As such, they are now preparing special nonmagnetic materials made of an alloy of gallium and indium as a precaution against the effects from magnetic fields that could also affect the xenon nuclei. And as their tests become more precise, the odds of witnessing the two isotopes respond differently to the axion force become greater.

"A Laboratory Search for a Long-Range T-odd, P-odd Interaction From Axion-Like Particles Using Dual Species Nuclear Magnetic Resonance With Polarized 129Xe and 131Xe Gas," appeared as an "Editor's Selection" in this month's *Physical Review Letters*.

Provided by Indiana University