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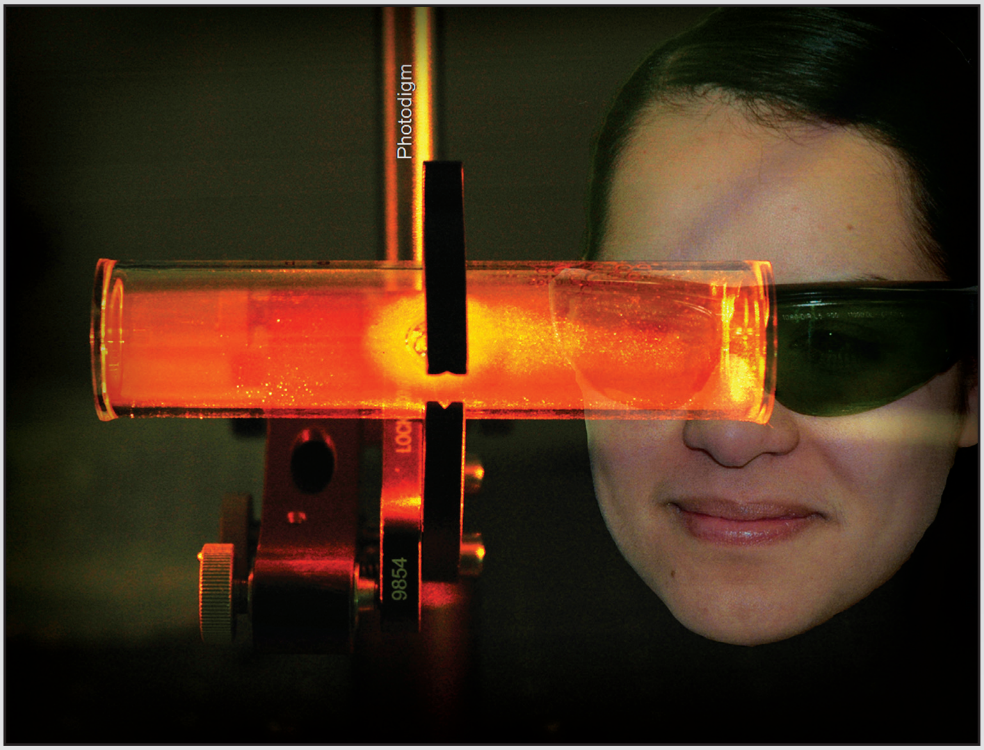
TECHNOLOGY MILESTONES

Air Force SBIR/STTR

SBIR Results "Bragg" Entry Into Atomic Physics Mainstream



Photodigm, Inc., engineer Judy Perez observes the faint, deep red glow of rubidium (Rb) vapor fluorescing under illumination of the company's new semiconductor laser, precisely tuned to match an electronic transition of Rb atoms. (Credit: Martin Achtenhagen)

AFRL Small Business Innovation Research (SBIR) partner Photodigm, Inc., developed a new generation of miniature, embeddable, semiconductor lasers that can accurately probe the internal states of atoms, a groundbreaking capability that will enable chip-scale atomic clocks, gyros, and entirely new types of high-energy lasers. Accordingly, the single-frequency, distributed Bragg reflector (DBR) device will soon undergo transition as a company-standard product meeting all targets for reliability and performance. AFRL scientists are working with these new lasers to develop atomic-physics-based technologies for a wide spectrum of sensors and instruments, including microscopic atomic clocks and inertial navigational systems for use in Global Positioning System–denied environments; highly sensitive magnetometers for detection of hidden threats; and advanced medical equipment for use in diagnostic procedures.

Because the novel DBR laser emits light of highly precise, stable frequency from a tiny, monolithic semiconductor chip, researchers are able to leverage this remarkable capability to shrink benchtop-scale physics packages to previously unattainable compactness, paving the way to a whole new class of handheld precision instruments for timekeeping, navigation, metrology, and magnetometry.

The outer shell electrons of the alkali metals—including potassium, rubidium (Rb), and cesium—act as highly sensitive transducers of changes to their environment. In their normal physical state, these atoms are in random motion, and the changes to their environment "average out" and are undetectable. However, researchers have observed that precisely tuned laser beams aimed at a low-pressure cloud of alkali atoms can act as a refrigerator, cooling and forming an aligned beam of atoms at temperatures close to absolute zero. These cold atoms form a new state of matter called a Bose Einstein Condensate, or BEC, the discovery of which was the subject of the 2001 Nobel Prize in Physics. When these atoms achieve the state of a BEC, they form the basis of an exquisitely sensitive transducer.