GEORGIA TECH RESEARCH

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VISIBLE LIGHT CHEMICAL LASERS OFFER APPLICATIONS FOR SPACE AND DIRECTED ENERGY

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For 20 years, scientists have been searching for chemically powered visible lasers. Now physicists at the Georgia Institute of Technology have developed what are believed to be the first two chemical laser amplifiers which operate in the visible spectral region.

The new laser amplifiers could have applications in space or in any environment where electricity to operate conventional lasers is not readily available, said Dr. James Gole, who heads the research group which developed the lasers. Conventional lasers require large electrical currents to generate the molecular changes that produce the laser effects.

The Gole group points out that these chemical lasers, developed in Tech's School of Physics, also make more efficient use of energy than electrical lasers.

"When you calculate how much energy you can channel into a system with a chemical reaction versus what you have to put in with normal electrical means, you are much better off with the chemical approach," Gole said. The Georgia Tech group has succeeded in producing both continuous and pulsed visible laser amplifiers running solely on the energy produced by chemical reaction.

Although the Tech researchers had been searching for a visible chemical laser on and off for a decade, the discovery of the continuous laser amplifier came as an offshoot of research on chemical reactions being done for the National Science Foundation.

"We recognized that we had observed the earmark of stimulated emission when we studied these chemical reactions," Gole explained. "We probably would not have recognized that very easily if we had not been familiar with the chemical laser work."

Chemical lasers operating in the lower energy infrared spectral region already exist, but Gole said visible lasers -- once developed to their full capacity -- will be easier to focus and operable with simpler equipment.

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The group, which also includes Stephen H. Cobb and J. Robert Woodward, is now attempting to convert the amplifier systems to laser oscillators. The two initially discovered Georgia Tech lasers produce green light, but Gole reports that additional research underway on similar chemical systems indicates the promise of blue and violet light.

The operation of any laser depends on creating a substantial population of highly excited molecules. When the number of highly excited molecules exceeds the number of molecules in lower energy levels, a population inversion exists which creates the potential for the lasing effect.

The continuous laser amplifier creates a population inversion by reacting molecules composed of three sodium atoms (Na_3) with atoms of halogen (chlorine, bromine or iodine). This reaction forms sodium halide molecules and molecules consisting of two sodium atoms (Na_2), which possess the excess energy required to place them in the higher energy levels needed for a population inversion.

As the excited sodium (Na_2) molecules release light, they relax to their lower energy ground state, where they immediately react with excess halogen atoms. This reaction takes these molecules out of the system, maintaining the population inversion and allowing the laser to operate continuously.

An important aspect of this process, Gole explains, is that the excited sodium (Na_2) molecules emit light at a faster rate than they can react with the excess halogen atoms.

The pulsed amplifier relies on the rapid transfer of energy from a highly excited metastable metal monoxide molecule to a thallium atom. The excited metal oxide molecule is formed through the reaction of silicon or germanium with ozone. Thallium was chosen because its ground state is split into two widely separated levels.

Upon vaporization, the thallium atoms are in the lower of the two energy levels. When they receive energy from the highly excited metal oxide molecules, the thallium atoms are pumped to an excited state with respect to the upper level of the thallium atom ground state, creating the necessary population inversion.

The search for chemically driven visible lasers has occupied researchers for two decades, Gole noted.

"The number of approaches that have been taken in attempts to make this laser would probably take about seven pages to list," he added. "There have been many possibilities, but until now, they all had some flaw."