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A. Chronological Bibliography of Publications Supported
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* Reprints received by AFOSR.

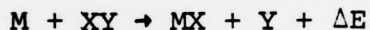
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B. Summary

As stated in the introduction to the original proposal, the use of chemical energy to drive a laser system is attractive from both the standpoints of efficiency of operation and energy storage capabilities. Many research groups have been and continue to be engaged in the search for such a chemical laser. Unfortunately, no one has yet succeeded. Although there are many metal-oxidant reactions



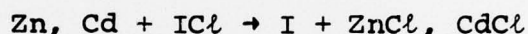
that are highly exothermic, and thus candidates for laser driving systems, two obstacles must be overcome to produce a chemical laser: the metal has to be produced in the vapor phase at high densities; and the energy liberated from the reaction must be channeled to produce a population inversion in the lasing species.

The first problem was attacked here through the use of a laser blow-off technique^{1,2} to provide the required high metal atom fluxes. With this method, the reactions of Cu, Al, Ba, and Sn with the oxidizers N₂O and F₂ were studied. In many instances, bright chemiluminescence was observed with an optical

multichannel analyzer, but all attempts to find laser emission were futile. It has since been found³ that the metal vapor produced by laser blow-off rapidly condenses to form minute suspended particles under conditions similar to those used in the above studies. Such particles destroy the Q of the laser cavity and would have prevented lasing even if a population inversion had been produced by the reactions. It is possible that there are conditions under which the formation of particles can be eliminated, but this problem severely limits the utility of this technique as a general diagnostic tool.

All of the reactions studied are sufficiently exoergic to produce the MX in an excited electronic state. However, studies of the various reactions under beam conditions show⁴ that, while some excited state products are formed, the bulk of the MX is found in the ground electronic state with much of the excess energy appearing as vibrational and rotational excitation. The energy that is deposited in the excited electronic states is also spread over many vibrational and rotational levels. Both of these problems may be overcome by transferring the energy stored in the MX, both vibrational and electronic, to an atomic system. Preliminary work has

been done on such a scheme using rare-earth metals, primarily Sm, as both the metal reactant to produce the energy and the atomic acceptors of the energy. Such a system holds promise since the rare-earths have low lying electronic states that can be populated by energy transfer and laser emission has been observed from these states.⁵ In an attempt to directly produce excited atoms, the reactions



have been studied. Angular momentum propensity rules indicate that the I atoms liberated should be predominately in the excited $^2P_{1/2}$ state leading to the possibility of laser emission at 1.315μ . A conventional photodissociation I^* laser has been built to probe these reactions systems for the presence of $\text{I}(^2P_{1/2})$.

Since ground state reactants lead primarily to ground state products, work is currently under way to investigate the reactions of excited state species to see if the production of excited state products can be enhanced. One potential laser system has been investigated. A doubled, high power Nd^{3+} : YAG laser was used to excite I_2 to the B state which was then

reacted with F_2 . Although laser emission from the I_2 as well as chemiluminescence from the IF was observed, no laser transitions in IF were found.

Although no chemically-driven laser emission has been found, several problems have been delineated and the direction of future effort indicated. A way must still be found to produce large metal atom concentrations. Certain possibilities, besides the attempt to eliminate particle formation in laser blow-off generation, include the use of exploding wires and the dissociation of organometallic compounds. Effort must also be expended in the study of energy transfer from high vibrational levels of metal diatomics to metal atoms. The search for schemes of direct production of excited atoms by chemical reaction should also continue. And finally, there should be further investigation of the reactions of excited species.

The above has been written as a summary of our attempts to make a prototype chemical laser. However, during this grant period significant progress has been made on developing basic techniques for understanding reaction kinetics on a microscopic level. This is attested to by the papers published during this period.

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