Experimental demonstration of a potential high-energy HCl chemical laser system

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As a candidate for high energy lasers, HCl chemical laser system based on the pumping reaction Cl+HI has some outstanding merits. Experimental results on some small devices have shown that it has attained the chemical efficiencies comparable to those of the typical HCl chemical lasers. The snag is that it is far more difficult to obtain large amount of Cl atoms than F atoms from the point of view of engineering. We proposed a viable scheme to solve this problem, viz, making use of the following weak exothermic reactions

$$F+Cl_2 \rightarrow ClF+Cl+3.2KCal/mole$$

This can transform the easily obtainable F atoms with high efficiency in engineering into Cl atoms needed. In order to test this scheme, we built a small subsonic flow chemical laser facility used as a planar wave-slowing configuration to couple 1 KW order microwave power at 2.45 GHz into the gas flow of SF_6/He, thus provides F atoms in a large volume homogeneous discharge plasma. With the injection of H_2 gas upstream of the optical cavity, we get HF laser output in the order of 1W. Then, enough amout of Cl_2 gas was injected about 15 cm upstream of the H_2 injection hole, leading to a total quenching of HF laser action as was expected. If a certain amount of HI was mixed in the injecting H_2 gas flow, HCl laser output in the order of 1W could be achieved. The spectrum of HCl laser output was identified by a DF laser energy analyzer. As the aim of this experiment was solely to demonstrate the feasibility of the scheme, no attempt was made for the optimization of gas mixing, optical axis position and cavity parameters. However, a HCl laser with an output power comparable to that of a HCl laser can easily be obtained under approximately the same condition of microwave power levels.

一种潜在的高能氯化氢化学激光体系的实验演示

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作为高能激光器件的候选方案，依据 Cl+HI 抽运反应的 HCl 化学激光体系具有若干突出优点。一些小型器件的实验结果表明，它已达到了可与典型的 HF 化学激光器件相匹敌的化学效率。问题是从工程角度来看，获得大量 Cl 原子远远难于获得 F 原子。我们提出克服此困难的一个可行方案是：利用如下弱放热的快反应

$$F+Cl_2 \longrightarrow ClF+Cl+3.2KCal/mole$$

将工程上易于获得的 F 原子高效率转化为所需的 Cl 原子。为验证此方案，我们建立了一个小型亚音速流动化学激光装置，其中利用一个平面慢波结构将一千瓦级 2.45GHz 微波功率耦合到 SF_6/He 气流内，并获得大体积均匀等离子体放电，以提供 F 原子。当在光腔段注入 H_2 气时，我们获得了瓦级 HF 激射输出。然后，在 H_2 注入孔上游约 15cm 处注入足量的 Cl_2 气时，则如所预期的，HF 激射输出可以完全猝灭。这时如果在注入的 H_2 气流中混入适量 HI 组份，可获得瓦级 HCl 激光输出。利用了 DF 激光能量分析器以鉴定 HCl 激射输出的谱线分布。由于本实验仅仅为了演示方案的可行性，故未追求最佳的气体混合比、光轴位置和光腔参数。但在大致相同的微波功率情况下，很容易获得与 HF 激光器相当的 HCl 激光输出功率水平。