Four-Photon Pumped Stimulated Emission

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•The objective of this project is to develop, through international collaboration with KTH in Sweden, highly efficient multiphoton materials which convert IR light efficiently into the visible. This IR-to-visible up-conversion is useful for technological as well as biomedical applications.

•We have demonstrated, for the first time, an efficient conversion of a short pulse IR radiation at ~1770nm to 553nm in the visible by direct four photon absorption (Fig. 1). This strong four photon absorption creates a population inversion in a new chromophore (APSS), previously synthesized in our laboratory, to produce highly directional stimulated emission at 553nm, both in the forward and backward directions (Fig. 2). The APSS molecules in the solution do not have linear absorption in the spectral range from ~500 to 1800nm. However, when illuminated by the focused 1770nm infrared laser beam, a greenish fluorescence is clearly observable. Moreover, when the intensity of the pump beam reaches the threshold value, a highly directional coherent emission is clearly observable (Fig. 2). Pump energy dependence of the generated emission additionally confirms a four-photon nature of the phenomenon. Spectral narrowing compared to fluorescence confirms that it is stimulated emission (Fig. 3).

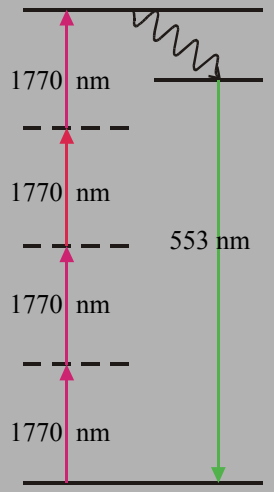

Fig1. Four photon excitation – diagram.

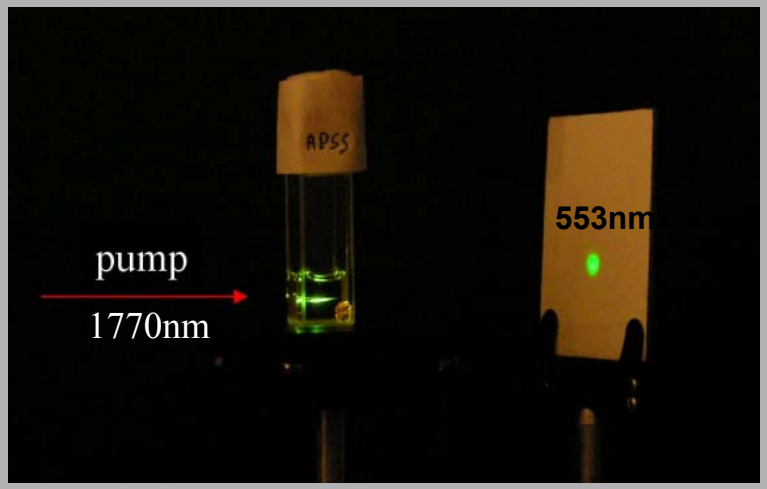

Fig2. Stimulated emission: λ_{pump}=1770nm, $\lambda_{emission}$=553nm

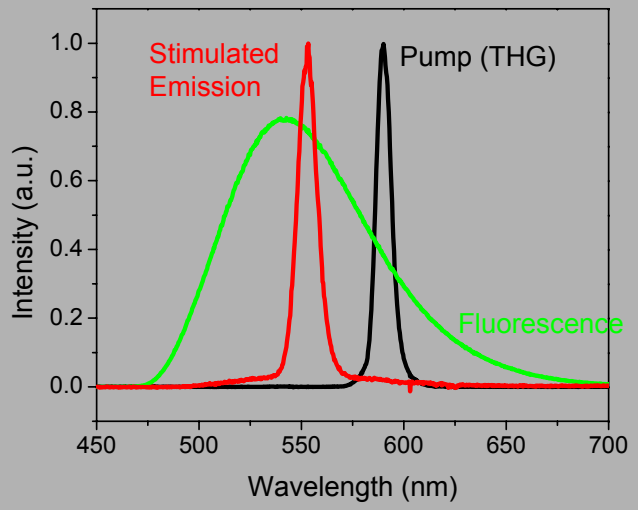

Fig 3. Spectra of the stimulated emission and fluorescence pumped by four-photon absorption.

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Education:

This work involved, a Senior Scientist (Physicist), a graduate student (Chemist), a visiting student (Electronic Engineer, Southeast University, China), and a visiting scholar (Theorist, KTH, Stockholm, Sweden). They worked in a highly interactive multidisciplinary environment to learn across disciplines. Furthermore, a workshop was organized jointly with KTH in Stockholm on "Multiphoton Processes" to train on new developments. The principal investigator published a monograph, "Nanophotonics" (Wiley publication), which provides students and researchers with educational materials on "Multiphoton Processes on Nanoscale."

Outreach:

A great deal of emphasis has also been placed on outreach. The PI gave a popular lecture on "Light and Multiphoton Effects" for high school students at the Buffalo Museum of Science (Nov. 13, 2003). This summer, he hosted two undergraduate students from other universities under the NSF REU Program. The PI has been active in outreach to the scientific community. He has offered tutorial lectures at various scientific meetings.