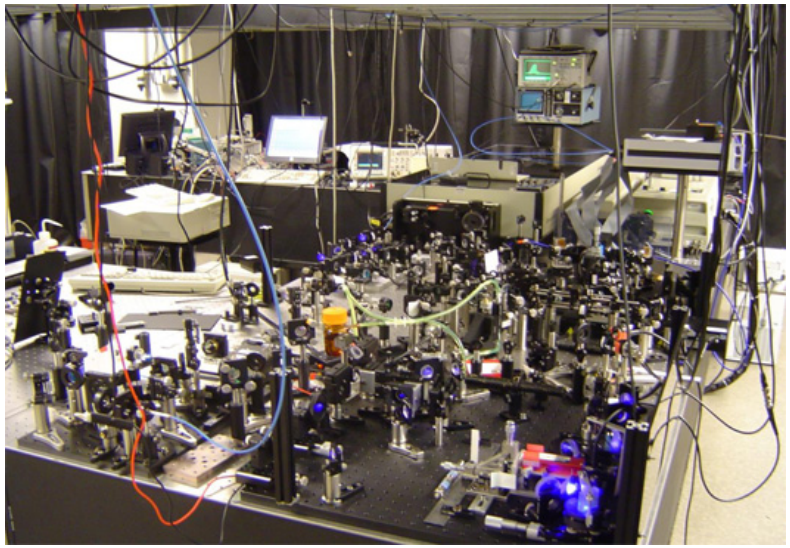
Incoherent Control by the Environment (ICE)

Matthew Kirschner

Quantum Control



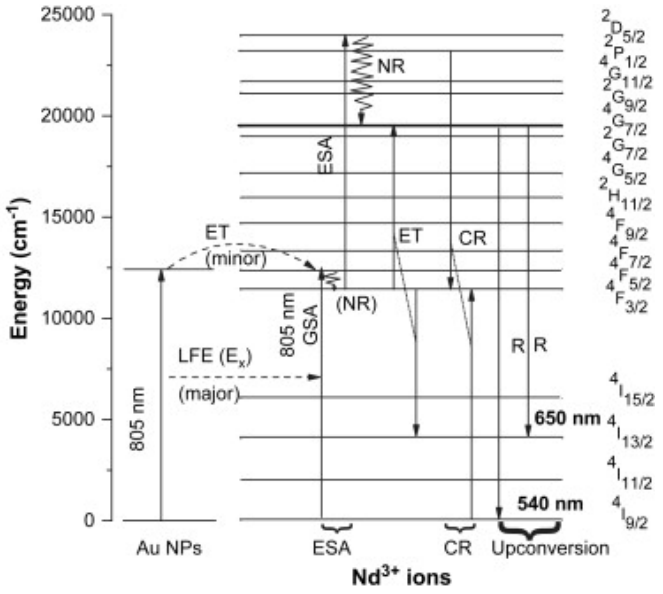
- Goal is to manipulate atomic and molecular dynamics phenomena
- Accomplished by shaping pulses of coherent light using a variety of parameters
- Set cost function and optimize various parameters using a machine learning algorithm

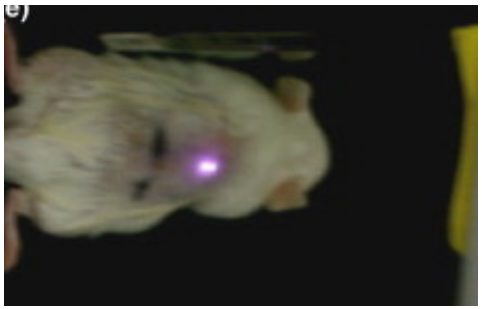
What is ICE?

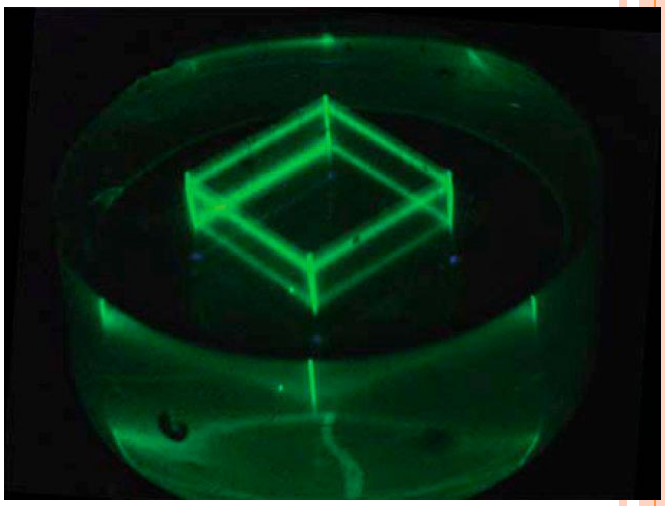
- Accomplishes quantum control with incoherent sources:
  - Incoherent radiation (gas of photons)
  - Gas of particles
- Significantly more accessible than traditional quantum control
- Has yet to be demonstrated experimentally

Current and Potential Applications of Energy Conversion

- Alternative Energy
- Authentication
- Medicine
- Next-Generation Displays





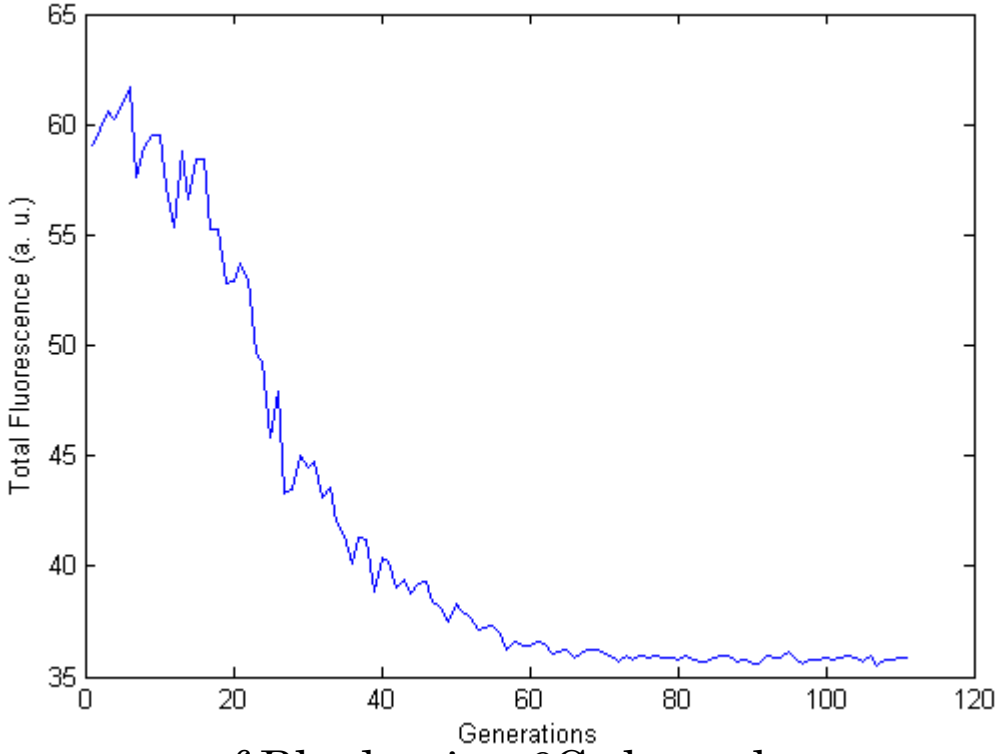


Our Goals

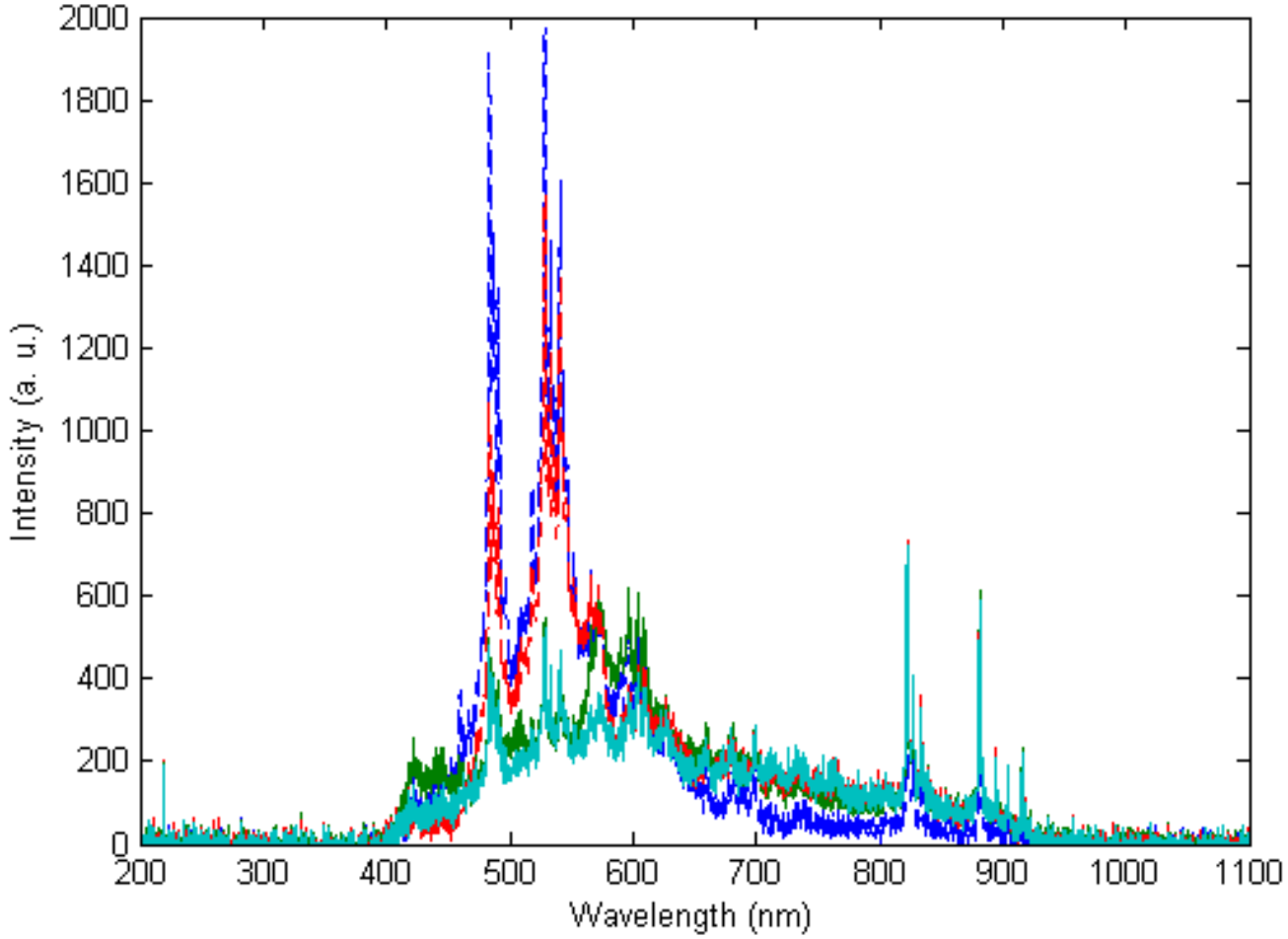
- Use incoherent radiation to control the energy level populations of several ions
- Observe non-linear processes, most notably energy up-conversion through ion-ion energy transfer
- Enable novel uses of energy converting materials

Optimizing Simple Systems

- We optimized the fluorescence of Rhodamine 6G (a well known fluorescence standard)

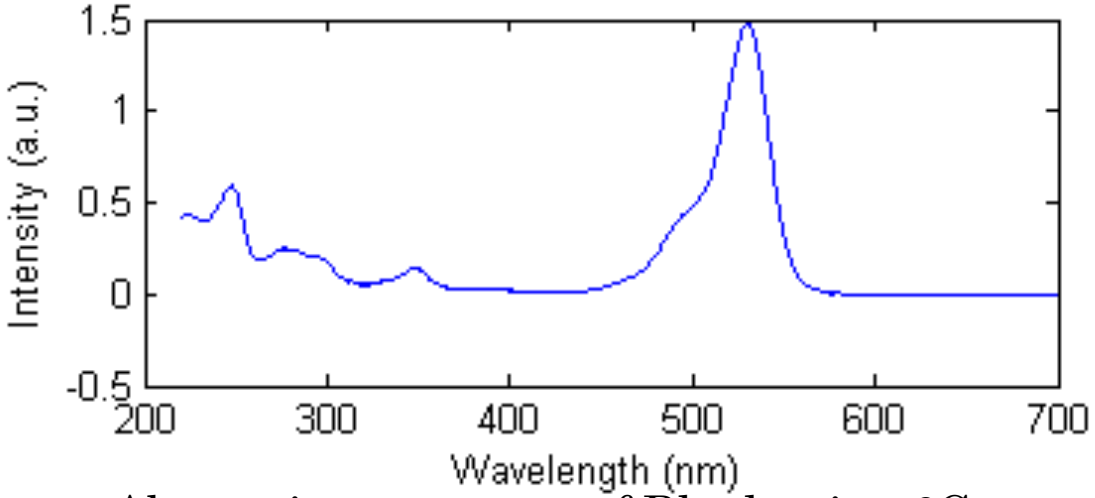


The fluorescence of Rhodamine 6G throughout an optimization minimizing the fluorescence



The resulting spectra from our optimizations maximizing and minimizing Rhodamine 6G's fluorescence

What it Means?

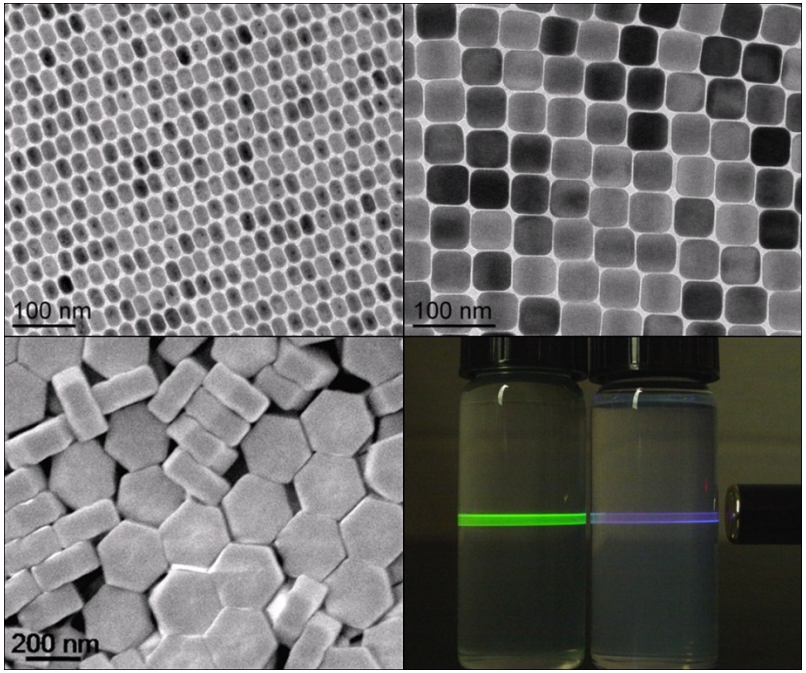


Absorption spectrum of Rhodamine 6G

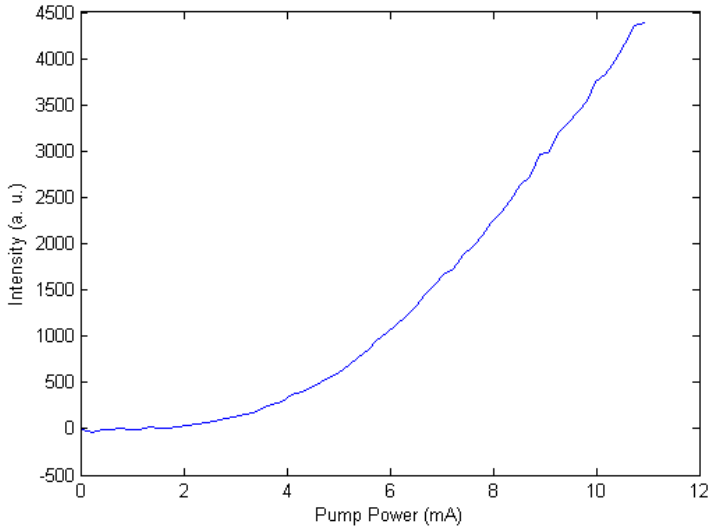
- We saw significant amplitude modulation around 450-600 nm
- This effect corresponds to the absorption band in Rhodamine 6G
- Our experimental set-up is sound

Sample Preparation

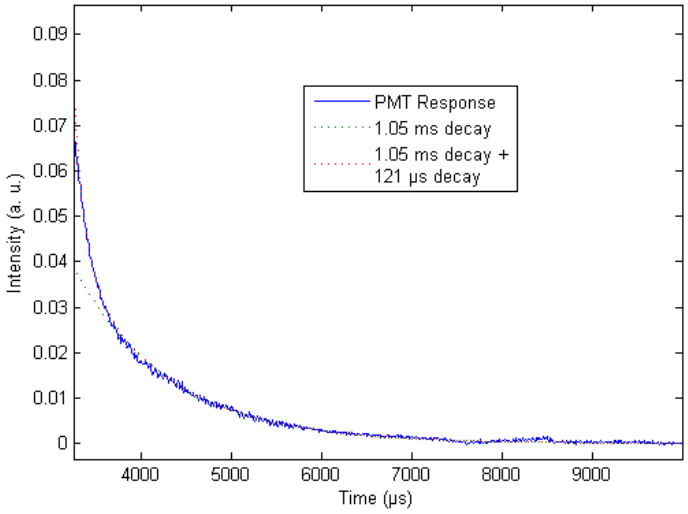
- Up-converting materials are difficult to prepare
- We now collaborate with Intelligent Material Solutions who manufacture numerous up-converting nanocrystals



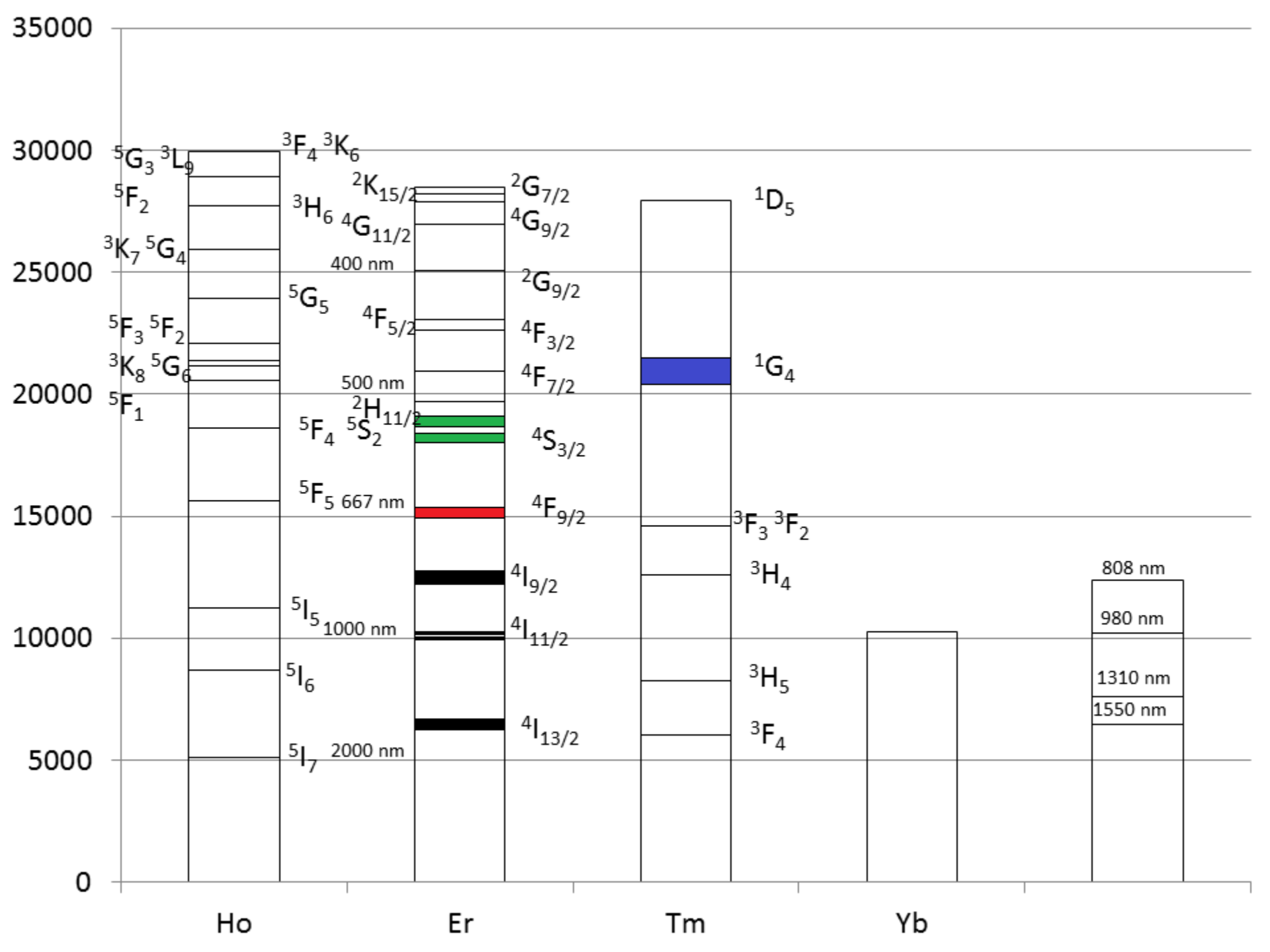
- Samples are highly non-linear with many long lived excited states



1550 nm power dependence of Yttrium Oxysulfide doped with Yb, Er, and Ho's 550 nm fluorescence

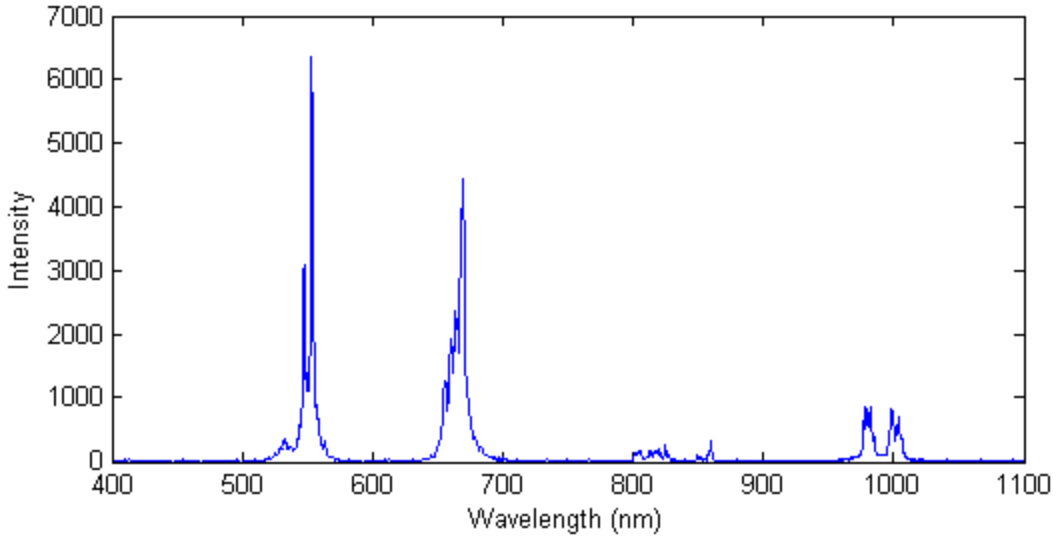


Fluorescence decay of Yttrium Oxysulfide doped with Yb, Er, and Ho

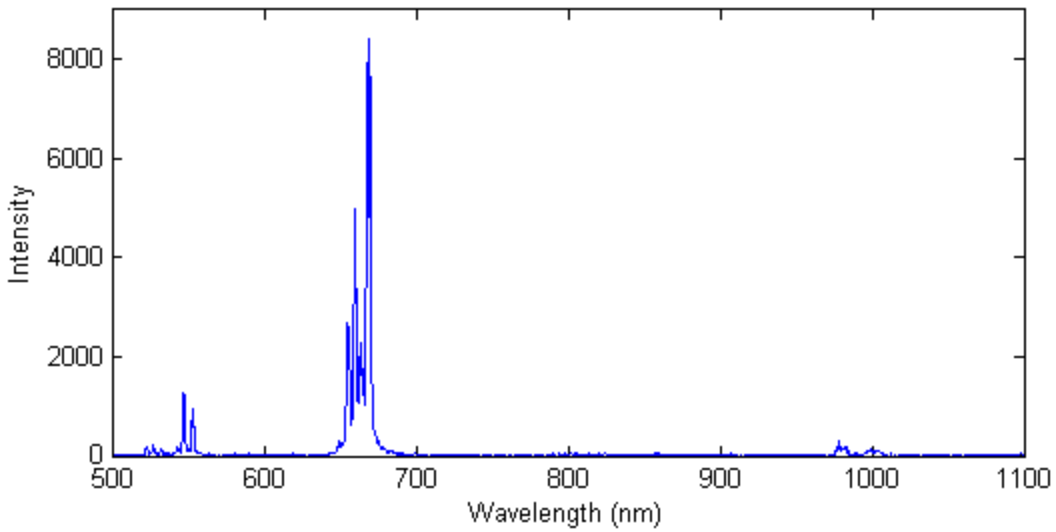

35000
30000
25000
20000
15000
10000
5000
0
Ho
Er
Tm
Yb
$^5G_3$ $^3L_9$
$^5F_2$
$^3K_7$ $^5G_4$
$^5F_3$ $^5F_2$
$^3K_8$ $^5G_6$
$^5F_1$
$^3F_4$ $^3K_6$
$^3H_6$
$^5G_5$
$^5F_4$
$^5F_5$
$^5I_5$
$^5I_6$
$^5I_7$
667 nm
1000 nm
2000 nm
$^2K_{15/2}$
$^4G_{11/2}$
400 nm
$^4F_{5/2}$
500 nm
$^2H_{11/2}$
$^5S_2$
$^2G_{7/2}$
$^4G_{9/2}$
$^2G_{9/2}$
$^4F_{3/2}$
$^4F_{7/2}$
$^4S_{3/2}$
$^4F_{9/2}$
$^4I_{9/2}$
$^4I_{11/2}$
$^4I_{13/2}$
$^1D_2$
$^1G_4$
$^3F_3$ $^3F_2$
$^3H_4$
$^3H_5$
$^3F_4$
808 nm
980 nm
1310 nm
1550 nm

Up-Conversion Luminescence with pumping at 1550nm

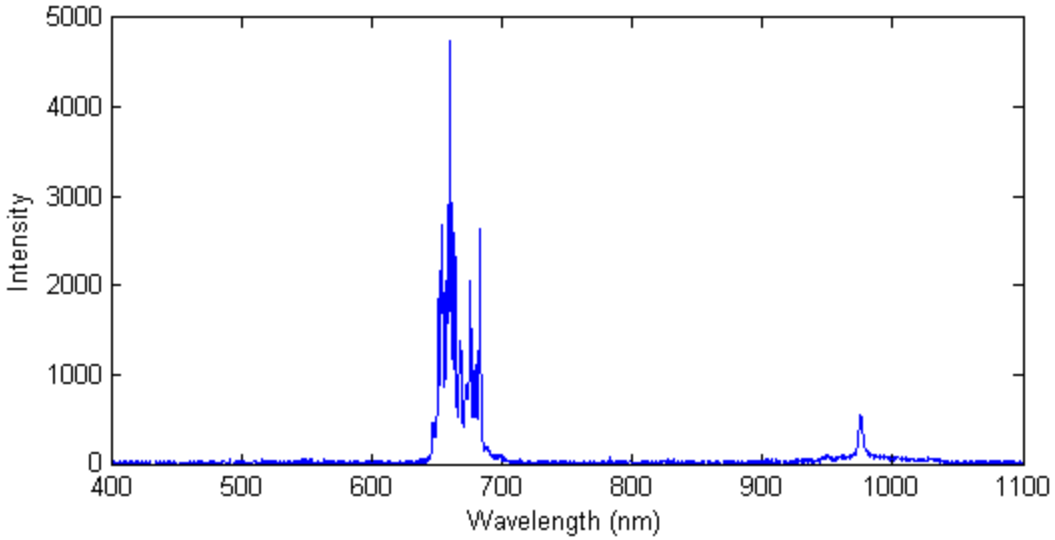
- Yttrium Oxysulfide doped with Yb, Er, and Ho



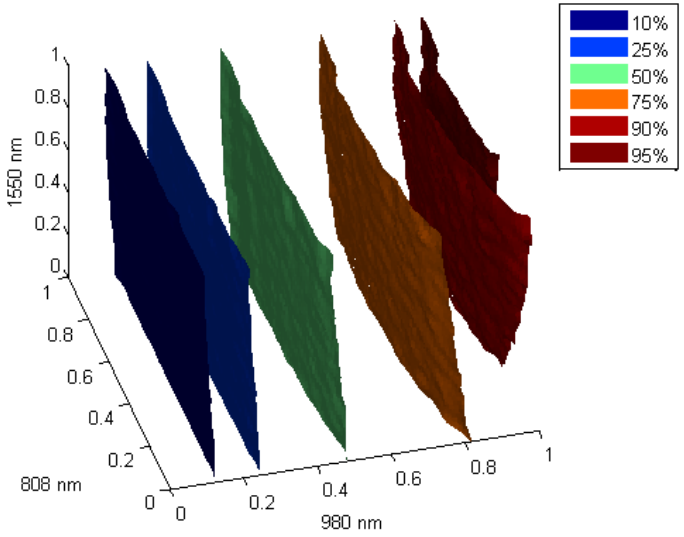
- Yttrium Oxysulfide doped with Yb, Er, and Tm



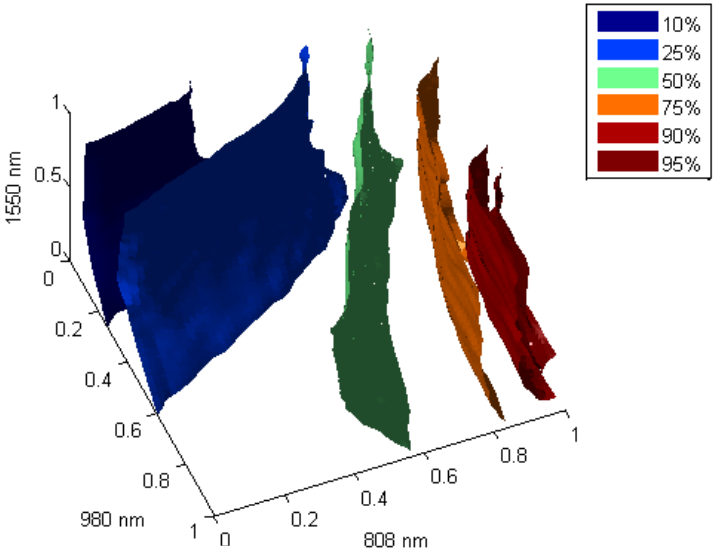
- Yttrium Oxysulfide doped with Yb and Er



Characterizing Landscapes (Yb/Er/Tm)

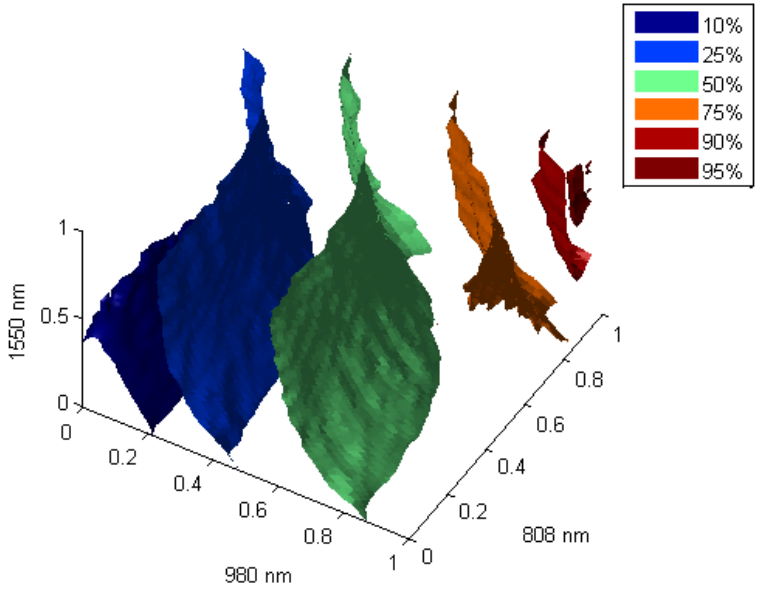


Blue Region



Green Region

Red Region



Moving Forward

- Analyze landscapes using HDMR analysis
- Further complicate landscapes by introducing additional light sources and time dependencies
- Gain deeper insight into up-conversion mechanisms

Acknowledgements

Intelligent Material Solutions

Princeton Plasma Physics Laboratory

Princeton Chemistry Department

The Rabitz Group, especially Francois Laforge