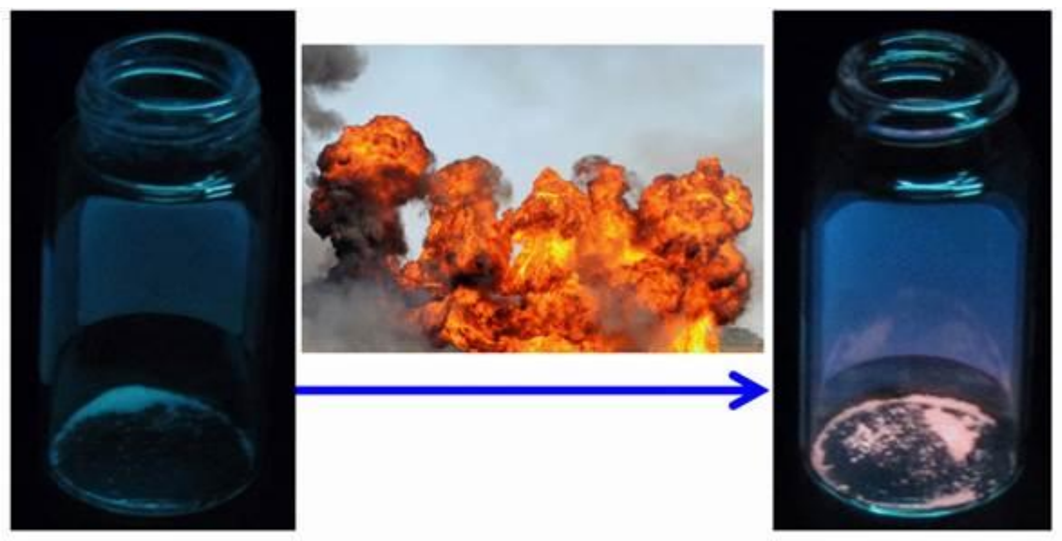
Construction of a Non-Laser-Based Fluorescence Spectroscopy System for Analysis of Heat Exposed Luminescent Nanoparticles

Jonathan Merkel
Gonzaga University

Advised by Dr. H. Eilers
Applied Sciences Laboratory
Institute for Shock Physics

Background and Motivation

- The neutralization of biological agents via explosions requires temperature measurements of inside the fireball of an explosion, which is currently unavailable.
- Luminescent nanoparticles (LNs), which are seeded into an explosion, are developed to monitor the temperature through optical properties that change with heat and time.
- Reference measurements of the optical properties of these materials are performed in the lab and in turn compared to samples that have been subject to explosive heating.
- The development of these temperature sensors requires screening a large number of materials which requires a non-laser-based fluorescence spectroscopy setup.



Objective

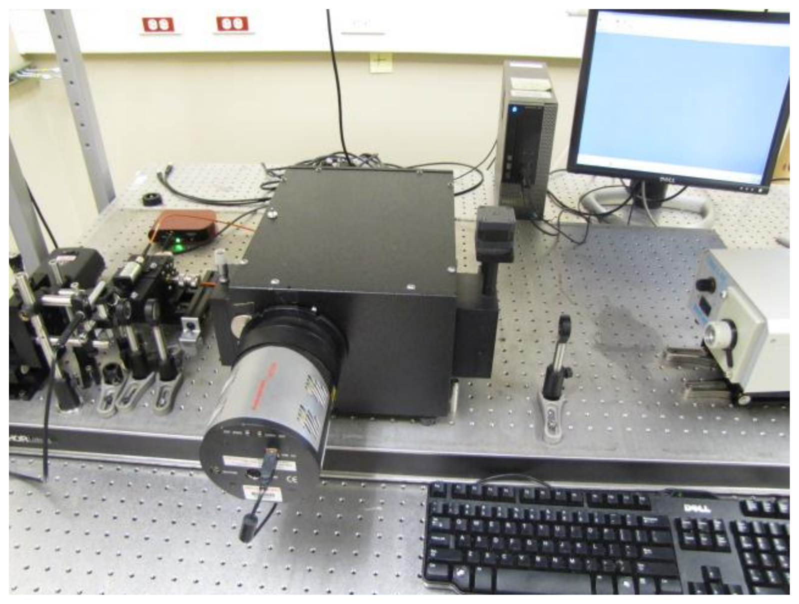
- Design, build, and test a non-laser-based fluorescence spectroscopy setup capable of measuring the fluorescence and excitation spectra of small amounts of sensor materials.

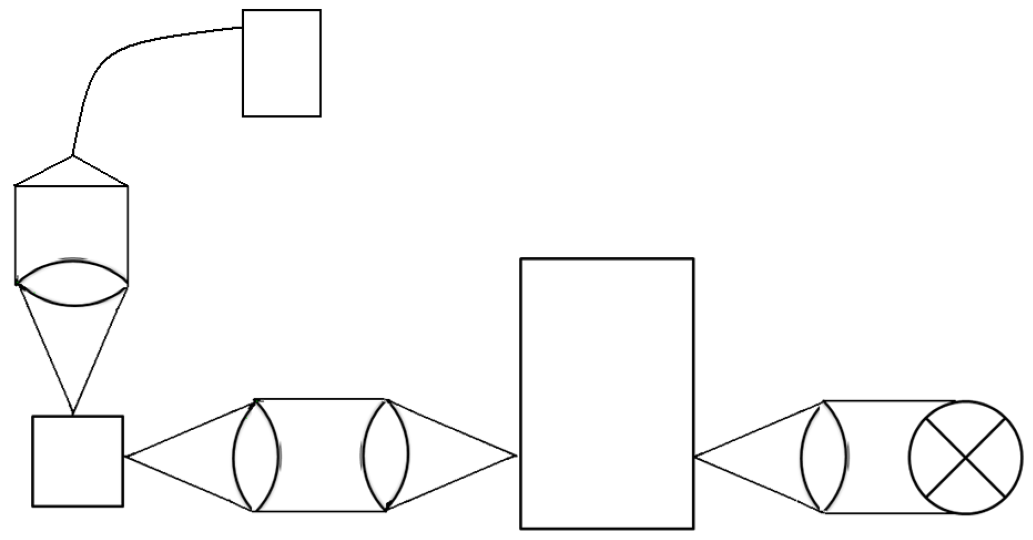
Experiments

- Excitation by small range of tunable wavelengths into selected energy levels of rare-earth ions.
- Excitation via UV light into charge-transfer band of host materials.
- Measure wavelength-dependent fluorescence intensities.

Spectrofluorometer Schematic

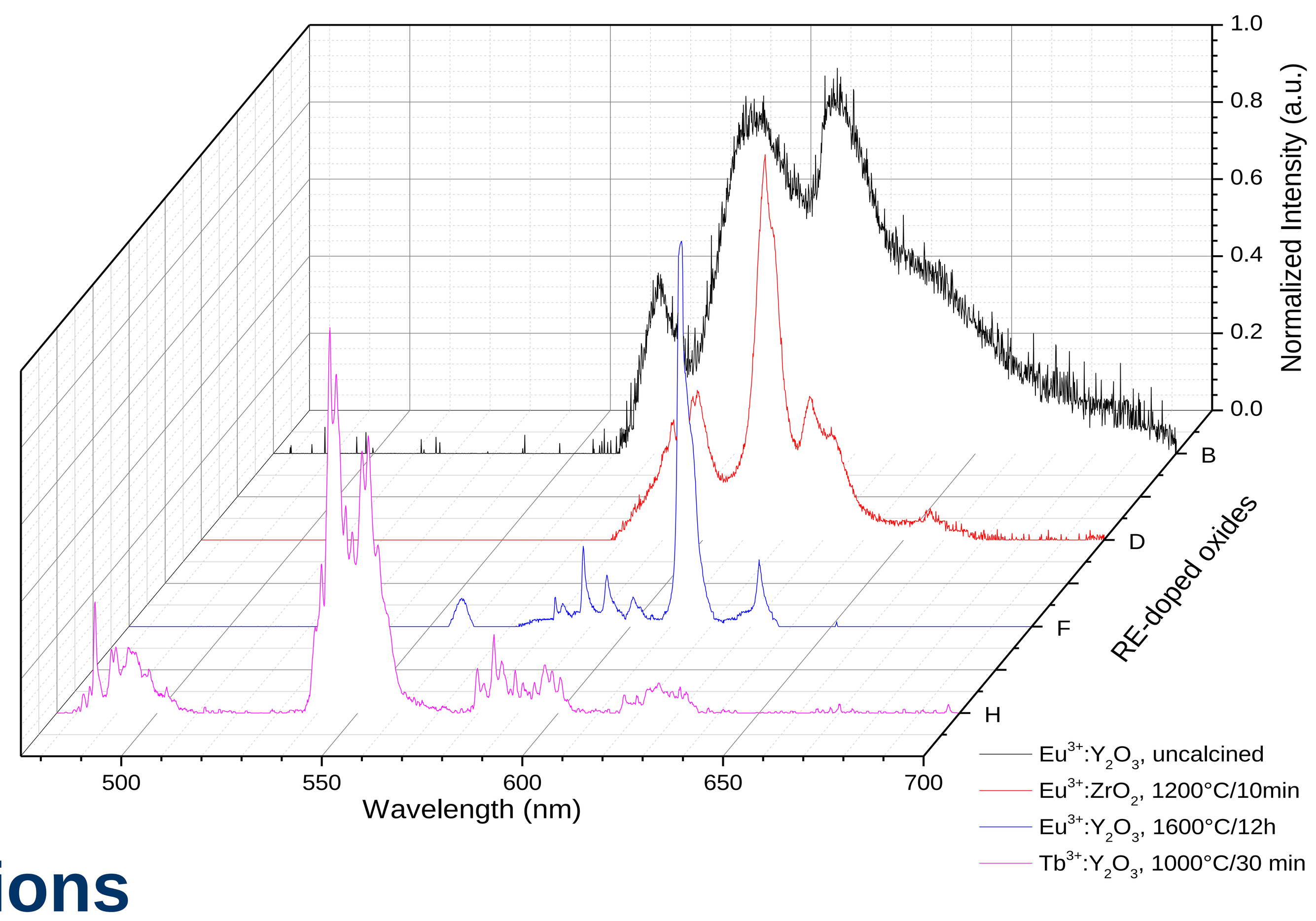
- Halogen lamp excitation method
  - 150 W, collimated incandescent light is focused into a monochromator (2.38 nm/mm linear dispersion).
  - Tunable wavelengths exit the monochromator and focus on the sample via a system of optical lenses.
- Ultraviolet light excitation method
  - Pencil style UV lamp stationed above the sample to illuminate the luminescent nanoparticles.
- Post-excitation fluorescence collection
  - Fluorescence light is collected by an optical lens and collimated into a microscope objective.
  - The objective focuses the fluorescence into a fiber optic cable which is fed to a spectrometer to measure the fluorescence spectrum.





Comparison of $Eu^{3+}Y_2O_3$, $Tb^{3+}:Y_2O_3$ and $Eu^{3+}:ZrO_2$

- Different emission peaks based on the RE dopant, core shell and calcination process.
- Sharper emission peaks from calcined samples.



Conclusions

- Between the two excitation methods, the system can efficiently excite RE doped oxides with a wide range of tunable wavelengths.
- The system can quickly collect fluorescence emission data.
- The more calcined the oxide, the sharper the fluorescence emission spectrum.

Washington State University — World Class. Face to Face.

This work was supported by the DOE/NNSA Grant No. DE-NA0000970

ISP