PHYS 403

Oral Presentation (100 pts)

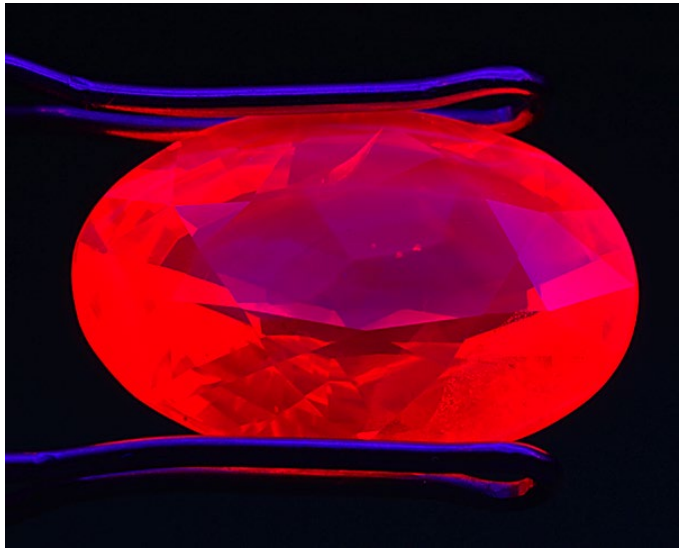
Name:_____ Eric Yu _____

CRITERIA	Eugene	Alexey
The whole day attendance (5)	5	5
Title was sent to instructor on time (3)	0	0
First slide has appropriate title, name, affiliation, date (3)	3	3
Scientific background, goal and motivation were clearly and correctly presented (20)	20	20
Research activities were clearly and correctly presented (20)	20	20
Results were clearly and correctly presented (20)	20	20
Technical aspects: good balance of text and figures, good quality figures, appropriate citations, correct spelling, correct number of significant digits, etc. (20)	20	20
Time management: good balance between Introduction-Procedure-Results-Analysis (3)	3	3
Spoke clearly, at a good pace, loud enough, etc. (3)	3	3
Finished on time and answered questions clearly and correctly (3)	3	3
Final Totals (100)	97	97

97

OTHER COMMENTS: The vertical scale on the final result should be ms not s.

Temperature dependence of fluorescence lifetimes of rubies



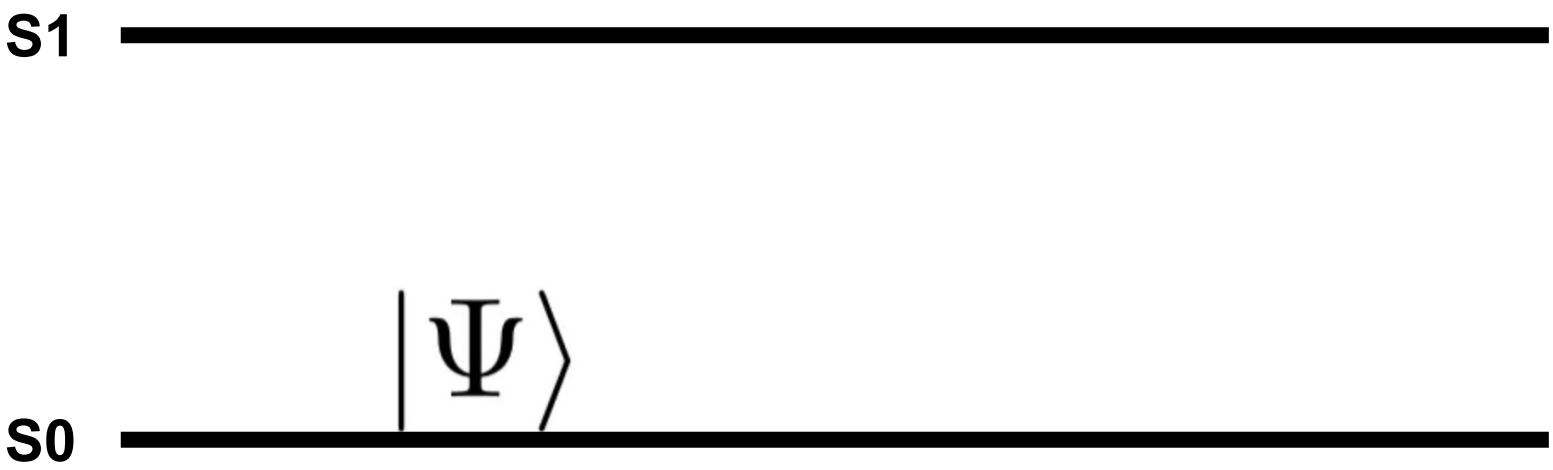
Courtesy ruby-sapphire.com

Eric Yu

Dept. of Physics, University of Illinois

March 7, 2023

The mechanism behind fluorescence

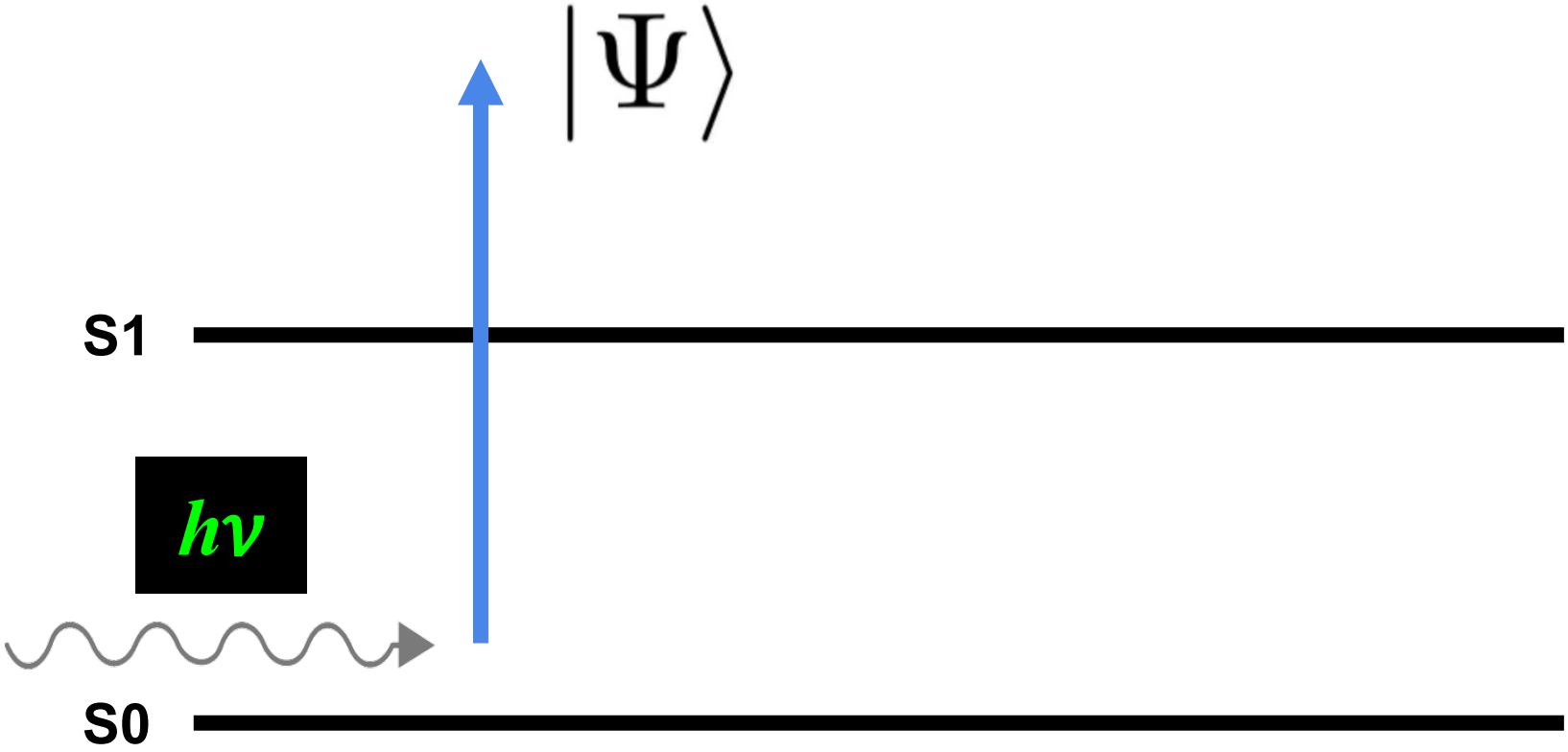


The mechanism behind fluorescence

STEP 1: Absorption

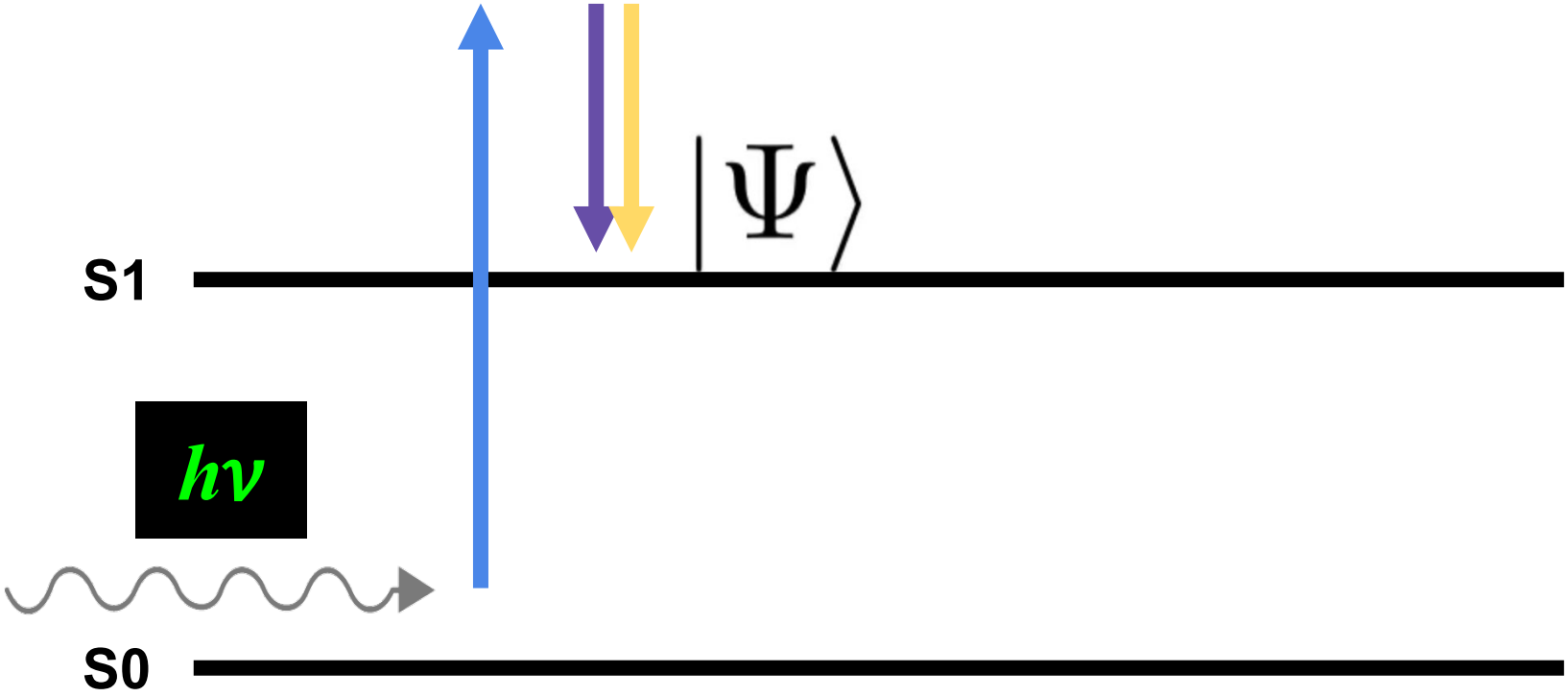
The mechanism behind fluorescence

STEP 1: Absorption



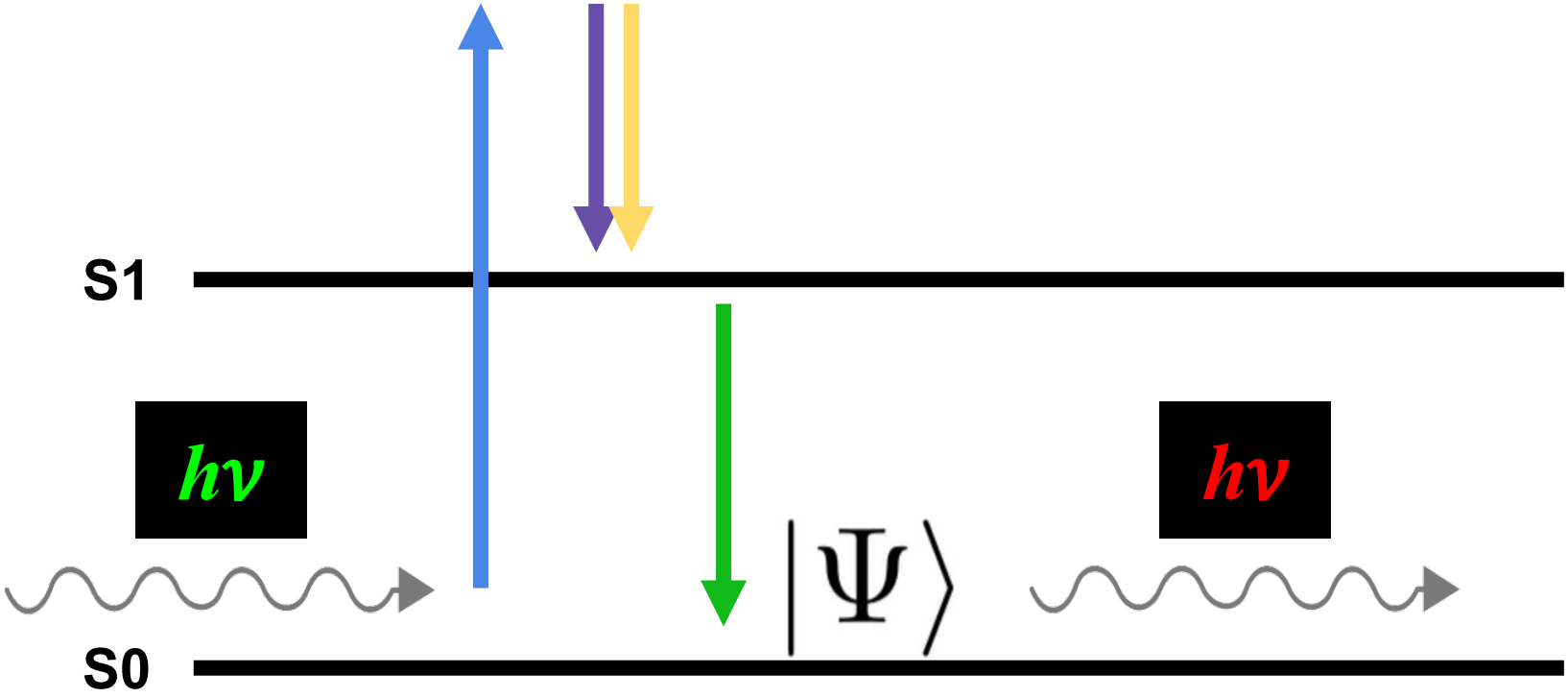
The mechanism behind fluorescence

STEP 2: Internal Conversion
and Vibrational Relaxation

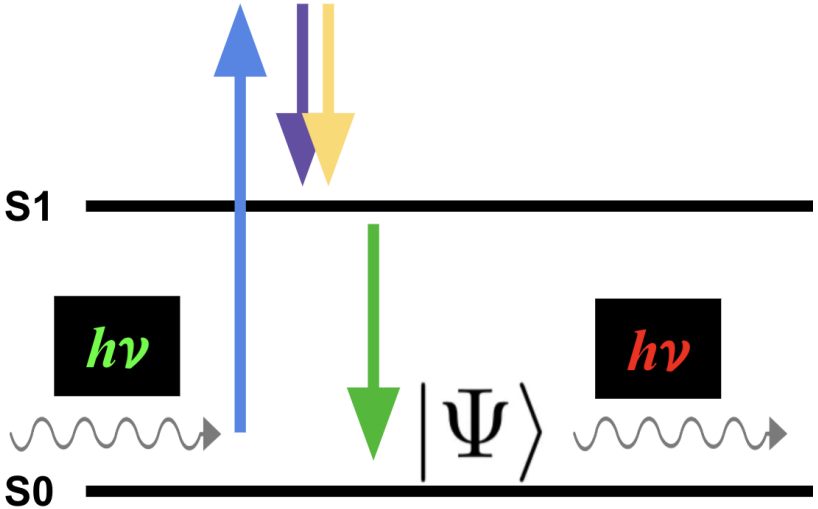


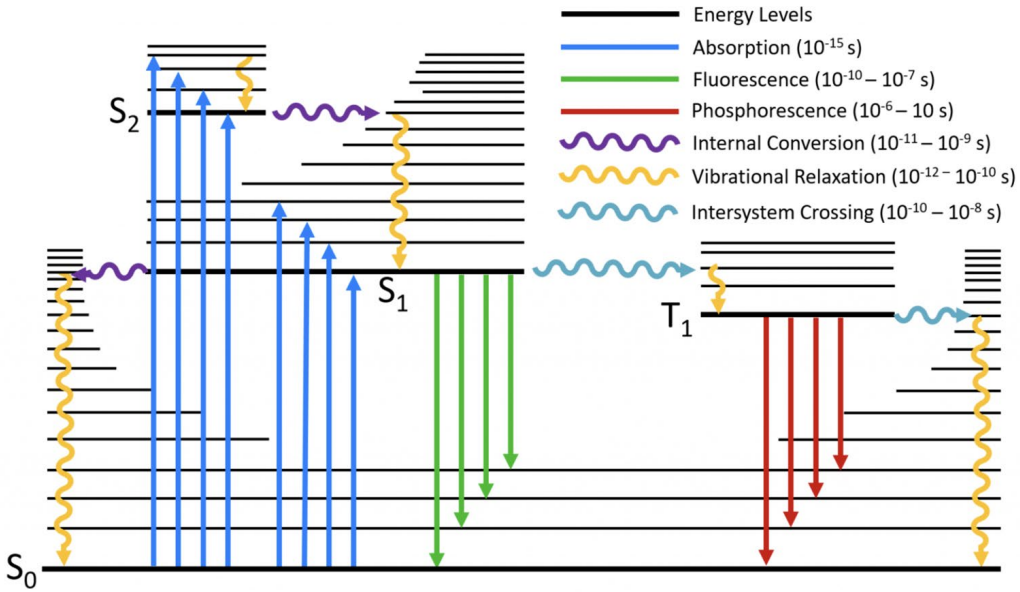
The mechanism behind fluorescence

STEP 3: Fluorescence



The mechanism behind fluorescence



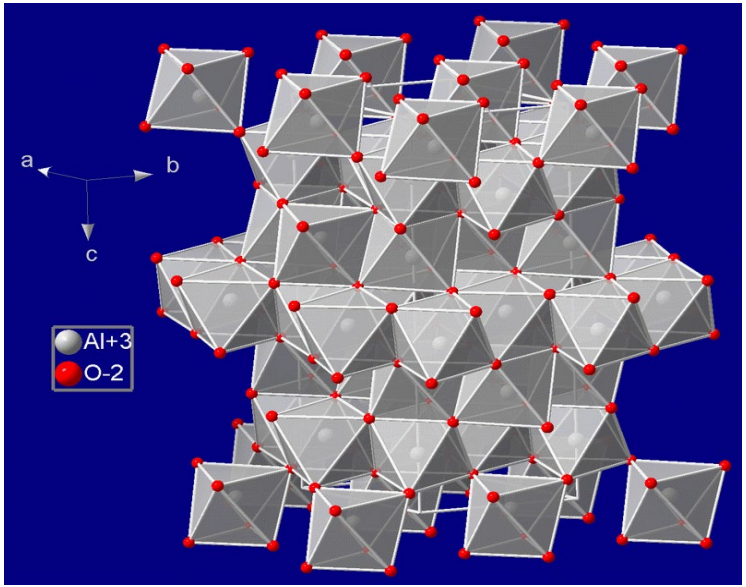


Perrin-Jablonski Diagram *Courtesy Edinburgh Instruments*

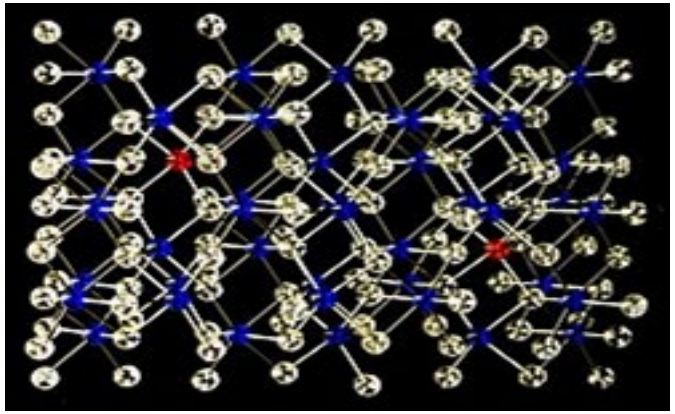
Fluorescence in rubies

CORUNDUM: Crystalline Al_2O_3

RUBY: Corundum with Cr^{3+} impurities



Crystalline Al_2O_3 *Courtesy Wikipedia*



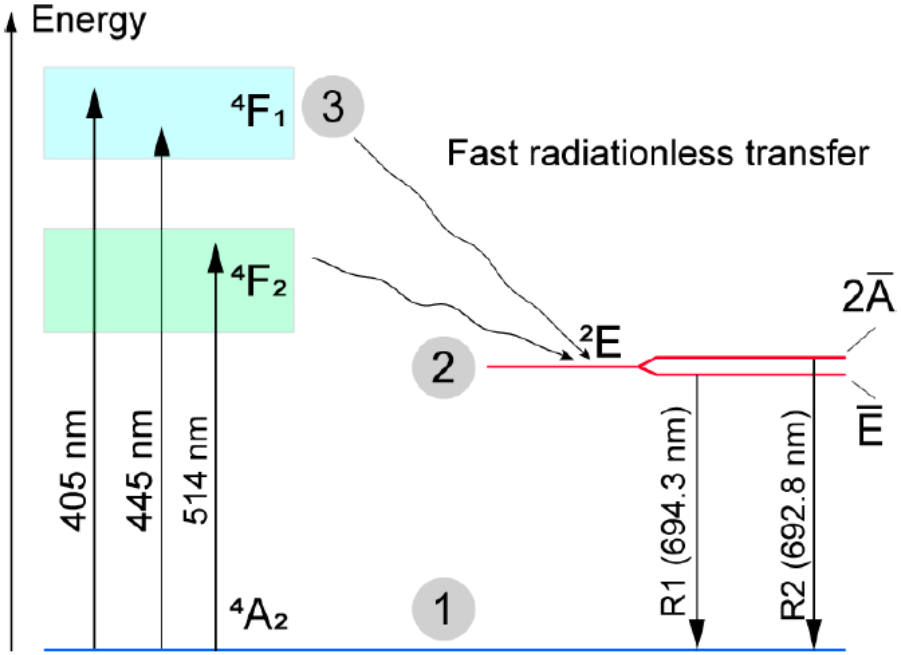
Ruby (Al_2O_3:Cr) *Courtesy Wikipedia*

Cr^{3+} impurities are the fluorescence species in ruby.

Fluorescence in rubies

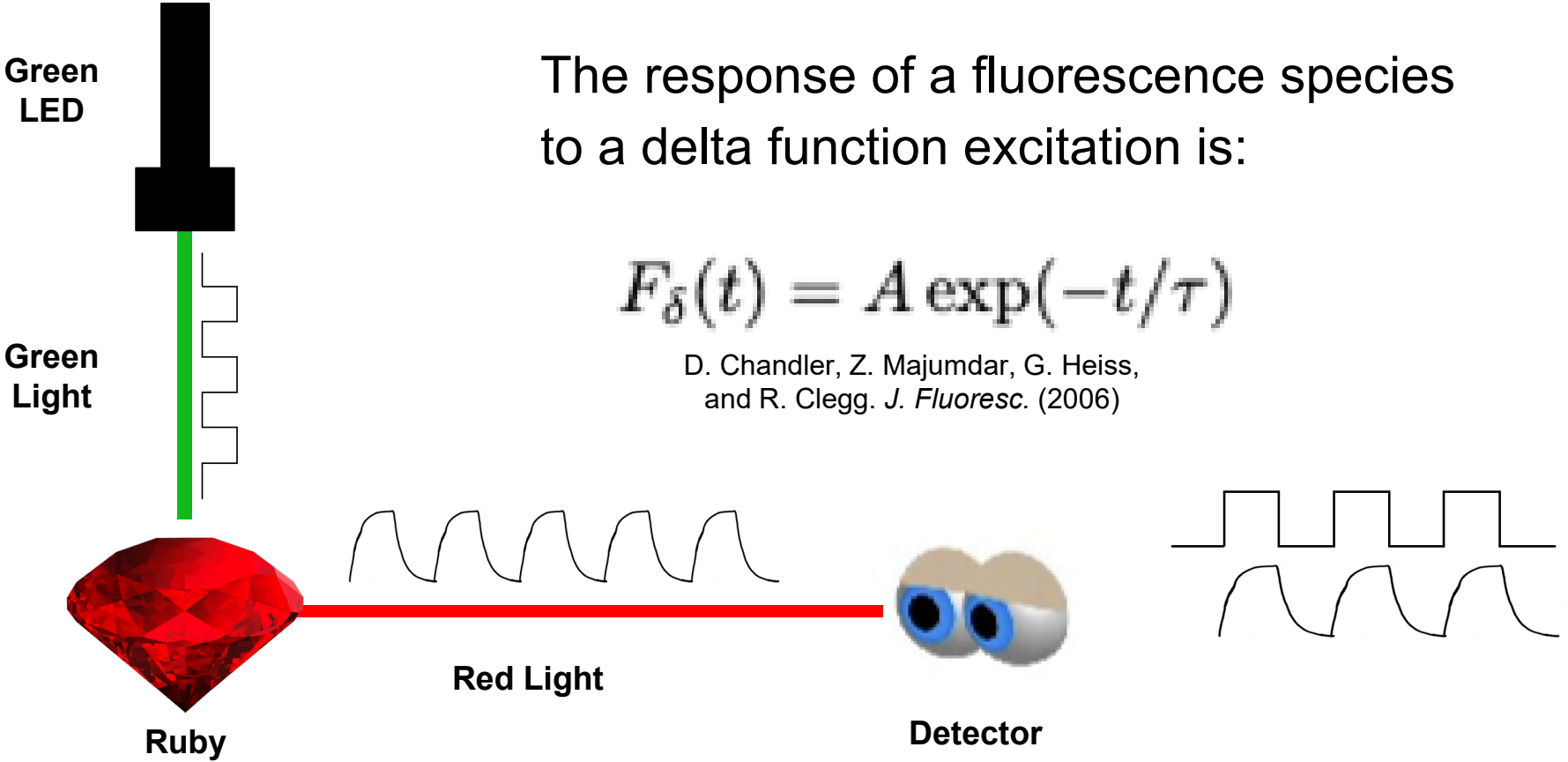
When the Cr^{3+} ions return to the ground state, they fluorescence red flight.

405 nm	UV
445 nm	VIOLET
514 nm	GREEN
694 nm	RED



Ruby Perrin-Jablonski Diagram
Courtesy PhysicsOpenLab.org

Measuring fluorescence lifetime



The response of a fluorescence species to a delta function excitation is:

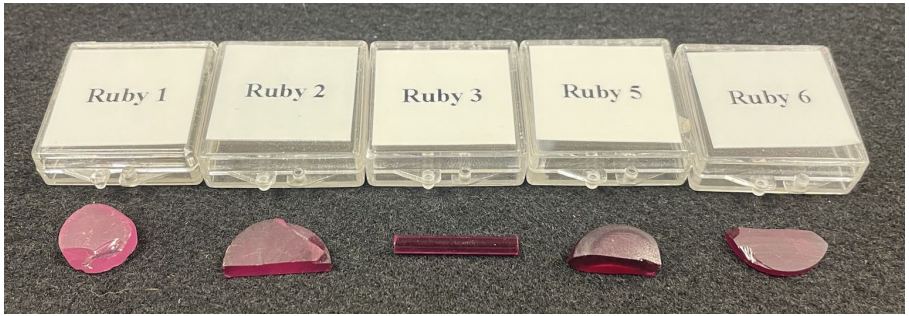
$$F_\delta(t) = A\exp(-t/\tau)$$

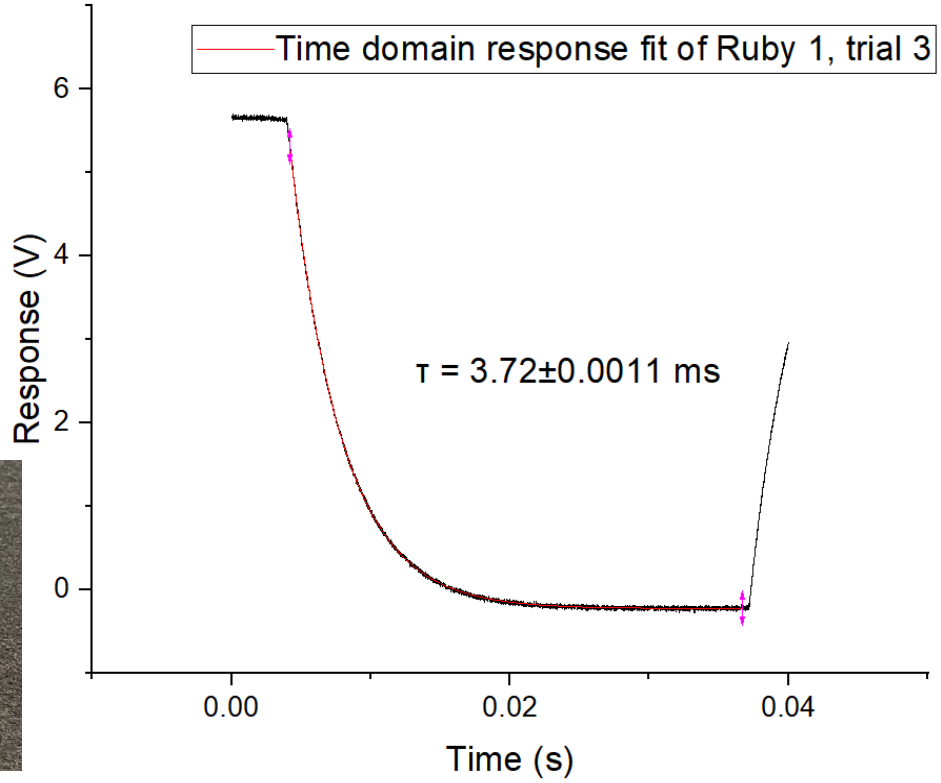
D. Chandler, Z. Majumdar, G. Heiss, and R. Clegg. *J. Fluoresc.* (2006)

Measuring fluorescence lifetime

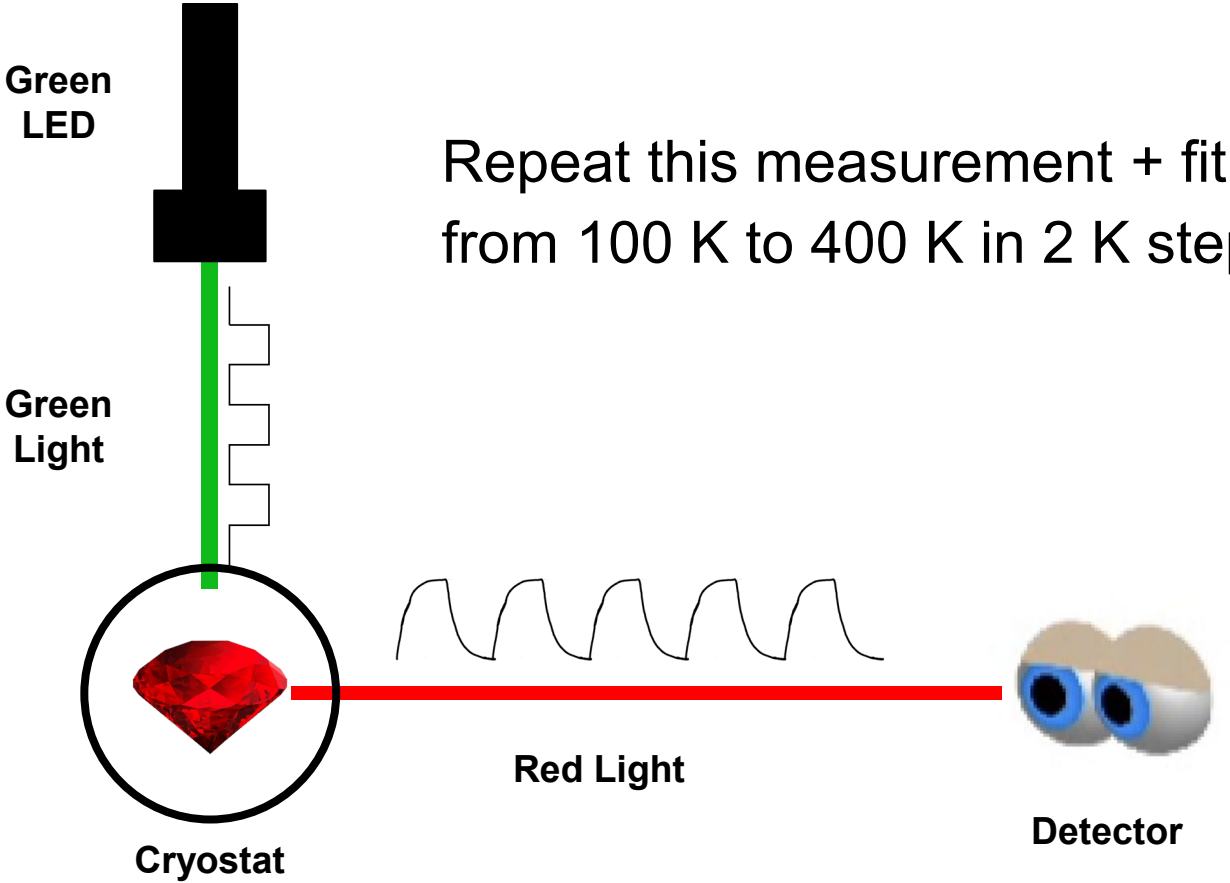
Fit data to exponential to find fluorescence lifetime.

$$F_\delta(t) = A\exp(-t/\tau)$$





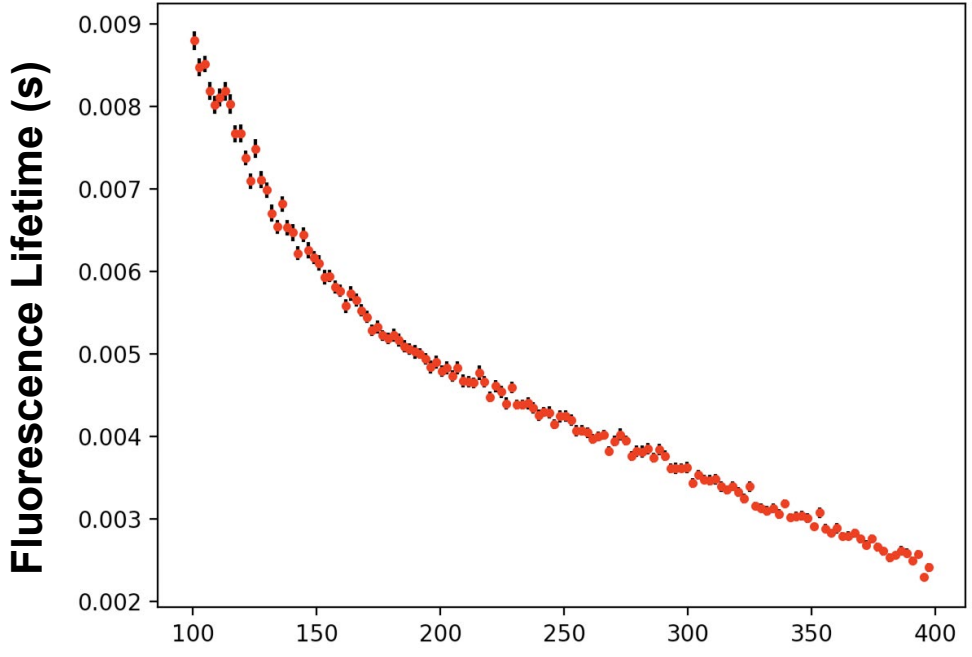
Varying temperature



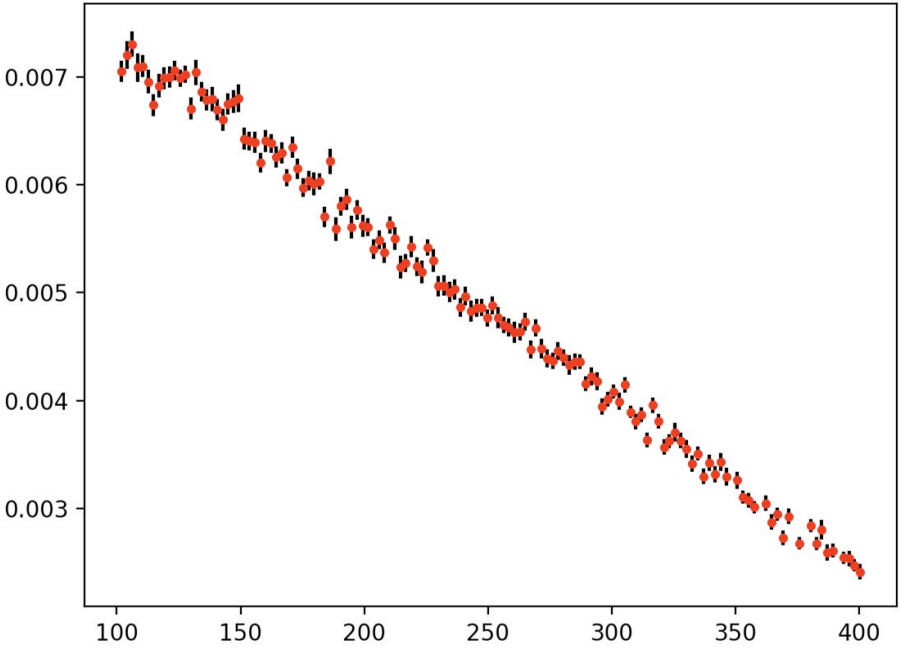
Repeat this measurement + fit for temperatures from 100 K to 400 K in 2 K steps.

Results

Ruby 1



Ruby 2

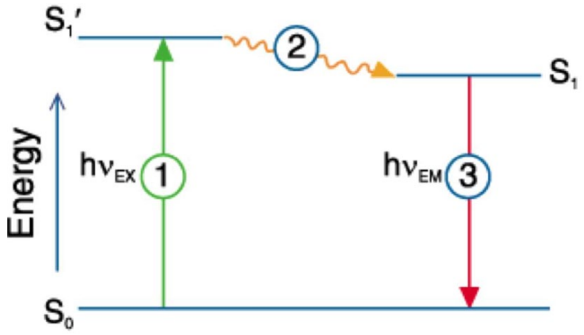


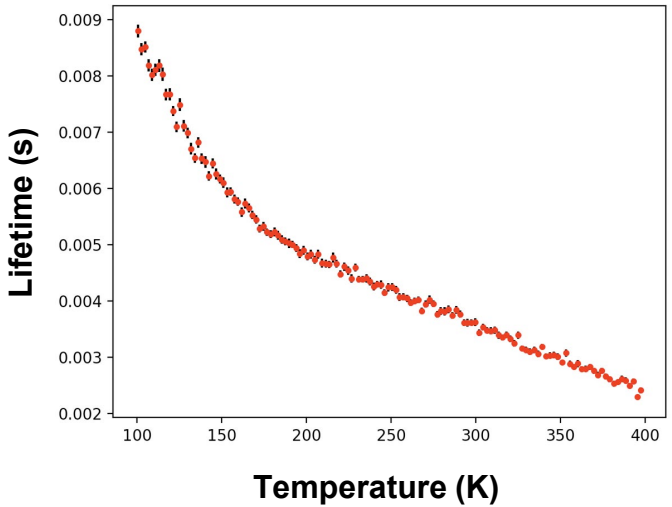
Temperature (K)

Conclusions

Lifetime decreases as temperature increases

- Makes sense?
- Linear?
- Frequency-domain measurement?
- Difference between samples?





Conclusions

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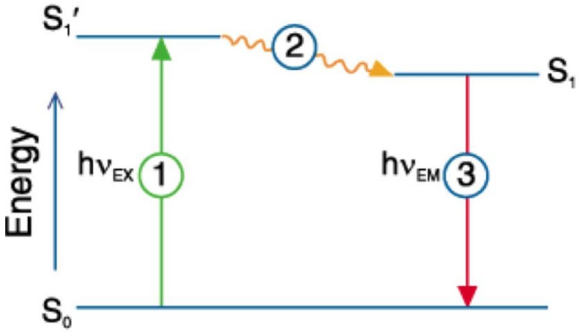

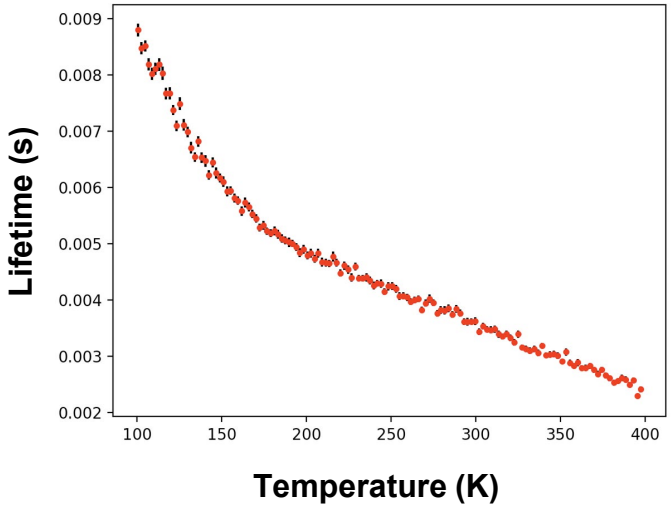

Questions?

References

1. D. Chandler, Z. Majumdar, et al. Ruby crystal for demonstrating time- and frequency-domain methods of fluorescence lifetime measurements. *Journal of Fluorescence* (2006). doi:10.1007/s10895-006-0123-7
2. J. Alcala, S-C. Liao, and J. Zheng. Real time frequency domain fibreoptic temperature sensor using ruby crystals. *Medical Engineering and Physics* (1996). doi:10.1016/1350-4533(95)00014-3
3. B. V. Thosar. On the Fluorescent Ion of Chromium in Ruby. *The London, Edinburgh, and Dublin Philosophical Magazine and Journal of Science* (1938). doi:10.1080/14786443808562133
4. B. Valeur and M. Berberan-Santos. Molecule Fluorescence: Principles and Applications. *John Wiley and Sons* (2012)
5. Ruby Crystal Fluorescence. *PhysicsOpenLab* (2020), link:https://physicsopenlab.org/2020/06/15/ruby-crystal-fluorescence/
6. A. Periasamy and R. Clegg. FLIM Microscopy in Biology and Medicine. *Taylor and Francis Group* (2009)