SAND2022-1773C

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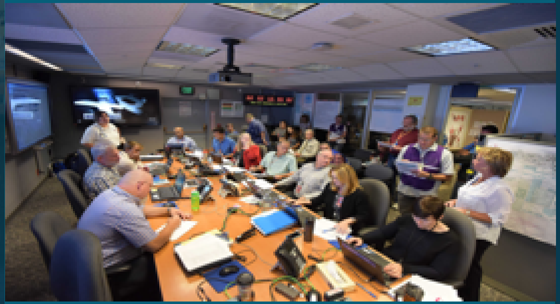
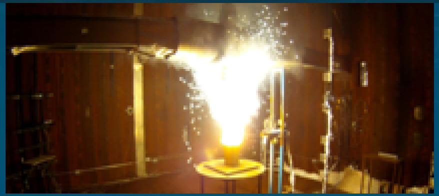
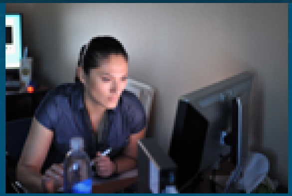
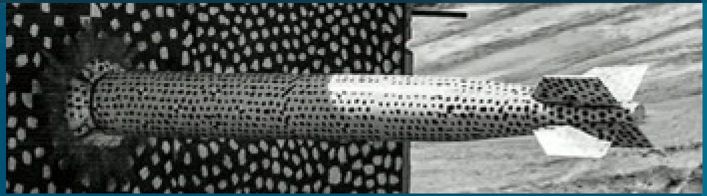


Winter Symposium







PRESENTED BY

Nathan Burt

U.S. DEPARTMENT OF ENERGY NNSA

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Outline

- Name
- School and Degree
- Organization/Manager/Mentor
- Project Working On/Details of Project

Name

Nathan Burt

ELECTRICAL
& COMPUTER
ENGINEERING

School and Degree

University of New Mexico – Electrical and Computer Engineering

- Starting Graduate School at the University of New Mexico in electrical engineering Fall 2021
- Researcher at the University of New Mexico
- Year Round Intern in 1659
- Advisor: Edl Schamiloglu
- Undergraduate: University of New Mexico – Electrical Engineering B.S.E.

Organization/Manager/Mentor

Organization 1659 – Advanced Capabilities for Pulsed Power

Manager: George Laity

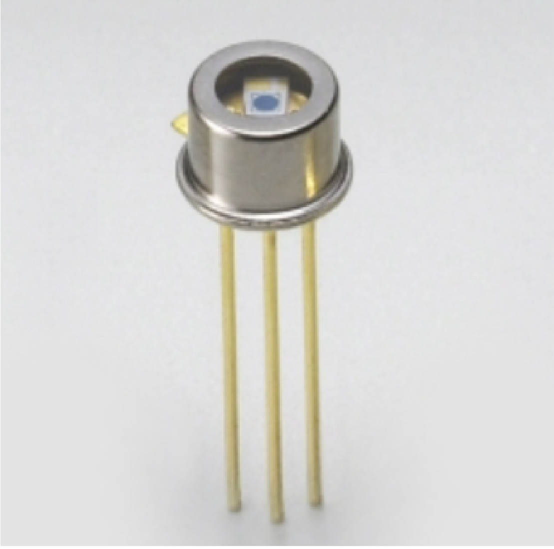
Mentor: Mark D. Johnston

“Department 1659 develops new capabilities and diagnostics for state-of-the-art pulsed-power facilities. We conduct experiments on Z and other pulsed power facilities in support of multiple programs, including **power flow physics**. We develop and support emission **spectroscopy** on Z, which is fielded on ~50% of experiments on Z. We maintain and operate SITF (Systems Integration Testing Facility) to develop subsystems for Z to a TRL of 6 prior to fielding on Z, including **magnetic field coils**, **gas puff z-pinches** and other capabilities. We are developing new systems for Z to provide in-situ **electrode cleaning** to mitigate or eliminate contaminant plasma formation on electrodes which limit current coupling efficiency.”

Project Overview

Experimental Objectives:

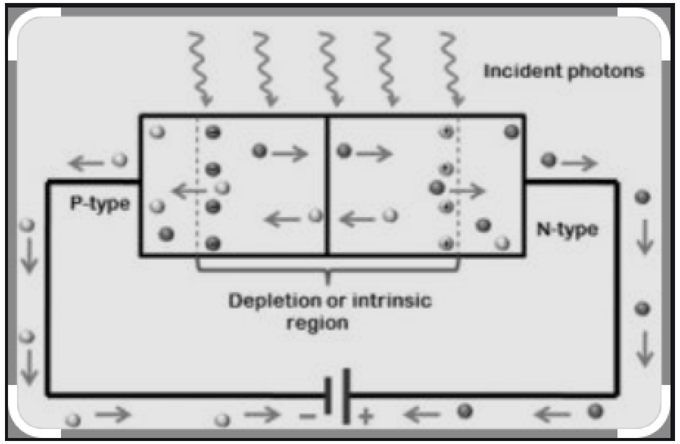
- Use Si pin photodiodes diodes to characterize the intensity (photons per unit time) of light from known wire/foil plasmas.
- Collect data at different wavelengths such as VUV (121 - nm) and visible (656 - nm); these wavelengths are the Balmer-alpha transitions and Lyman-alpha transitions of the hydrogen atom.
- Compare intensities between spectral regions in order to see differences in electron distributions and plasma evolution.
- Compare broadband visible and VUV emission from fine wires and foils (aluminum and stainless steel) to visible and VUV emission of the hydrogen neutral atom (Balmer-alpha and Lyman-alpha lines) by use of unfiltered and filtered photodiodes respectively.



Si visible spectra pin photodiode, Hamamatsu S5973

Photodiodes

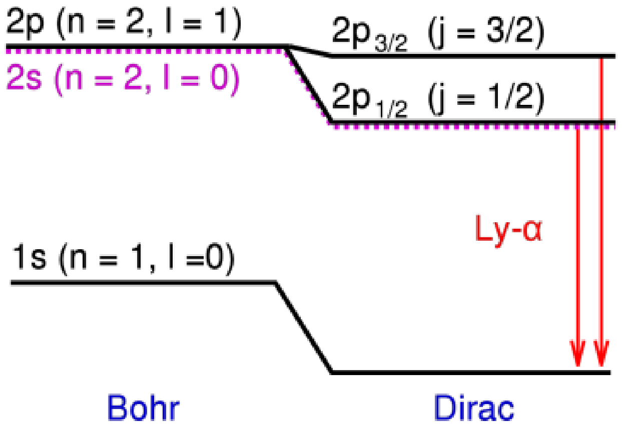
Photodiodes are semiconductor junction devices that use the photoelectric effect to convert light into electrical current. The photons emitted from a light source hit the junction of the diode and then add enough energy to excite an electron causing it to cross the junction gap. This flow of electrons is what makes up our current.



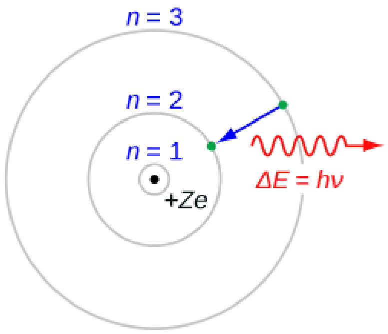
In order to get a good current signal we need a bright light source that will emit a lot of photons.

Hydrogen Lyman-alpha and Balmer-alpha Spectral Lines

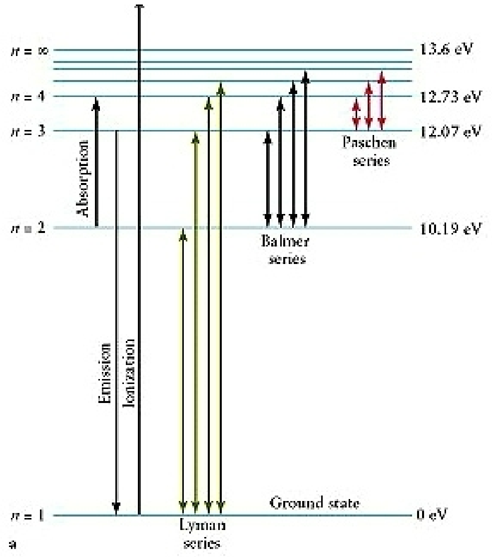
Lyman-alpha photons are emitted when electrons move from the n=2 orbital to the n=1 orbital. They are emitted with a wavelength of approximately 121nm.



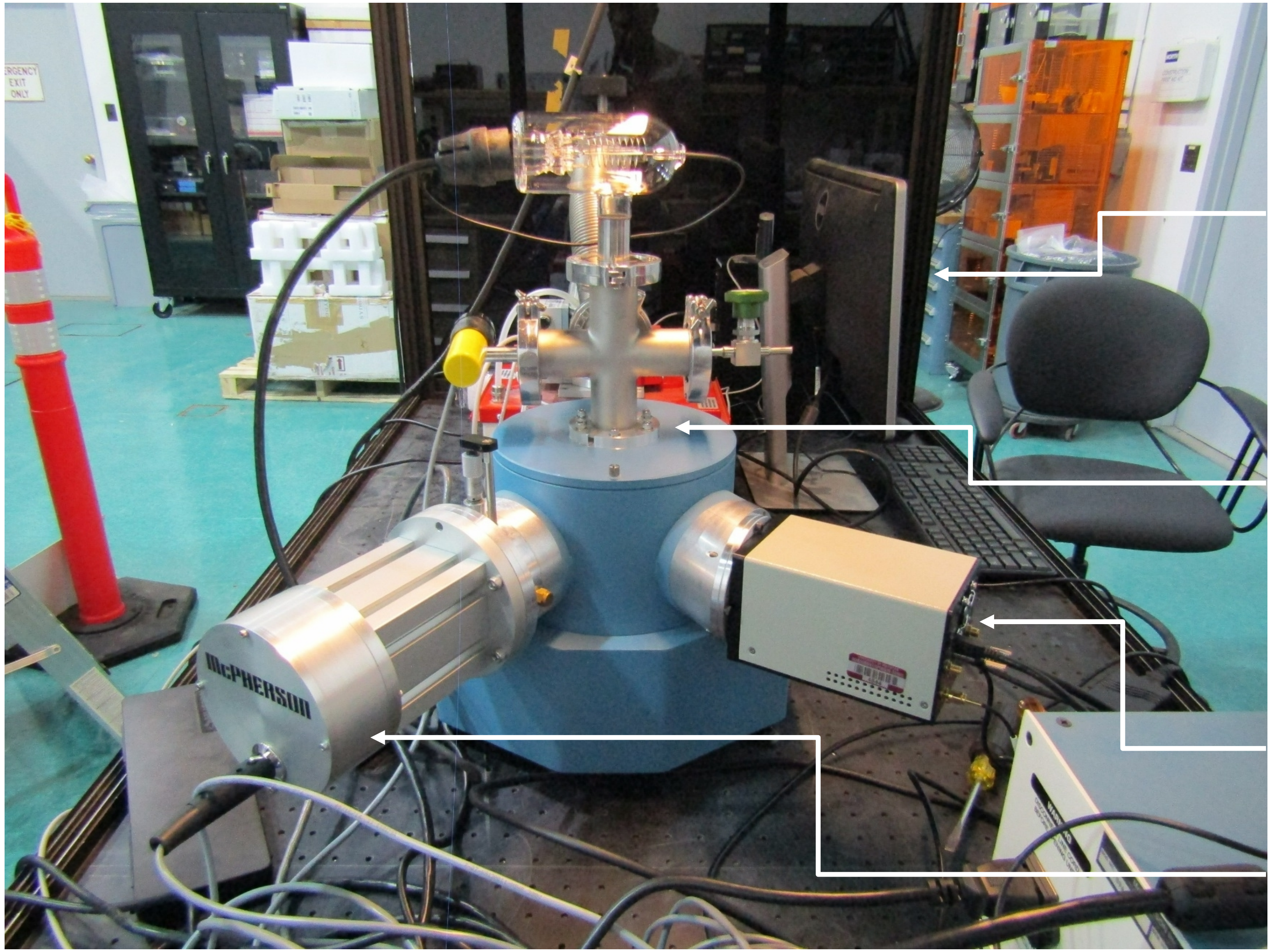
For Balmer-alpha, the line that we are looking at occurs when electrons move from the n=3 to n=2 states. The wavelength associated with the photon that is emitted is approximately 656nm.



Grotrian Diagram of the hydrogen atom



Experimental Setup



PC with camera and spectrometer control software

McPherson 234/302 Spectrometer

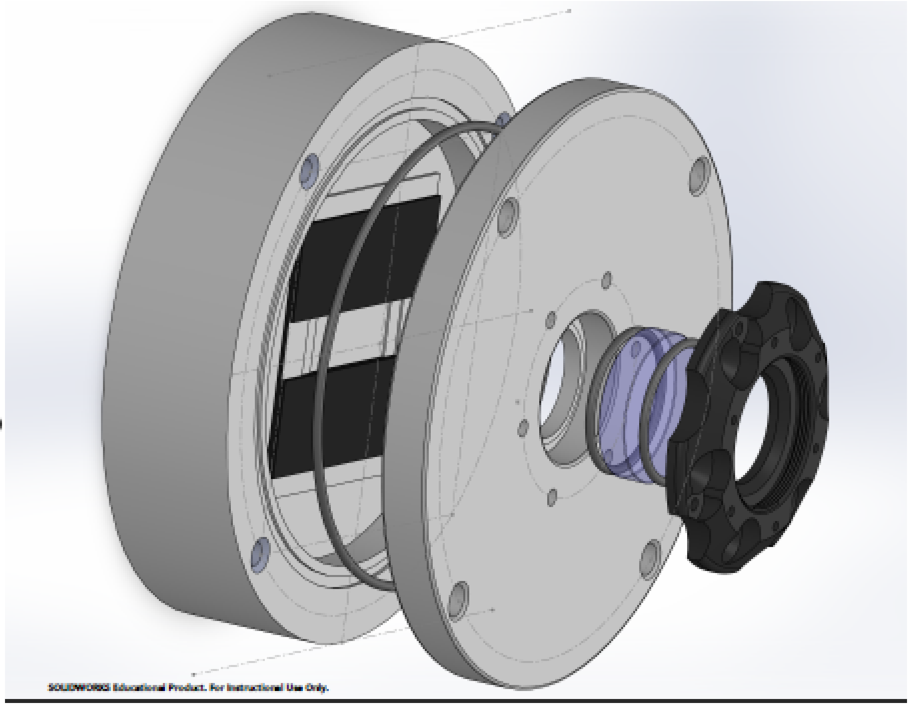
Photek iCMOS 160 VUV camera (Current System has a photodiode mounted here)

McPherson 632 D2 Lamp

Improvement in Experimental Setup

The previous photodiode housing had the photodiode sitting approximately 14.5 cm away from the exit slit attached to the McPherson spectrometer. Intensity of light was far too low to detect at this distance due to the light spreading out after exiting the slit.

The new system (shown on right) decrease that distance to less than 3 cm. This will allow the photodiode to be hit by at least 23 times as much light. This number is found using the following equation: $(\frac{14.5}{3})^2 = 23$.



Light Sources

The light source will be plasmas created in experiments involving contaminant desorption from wires via the small pulser.

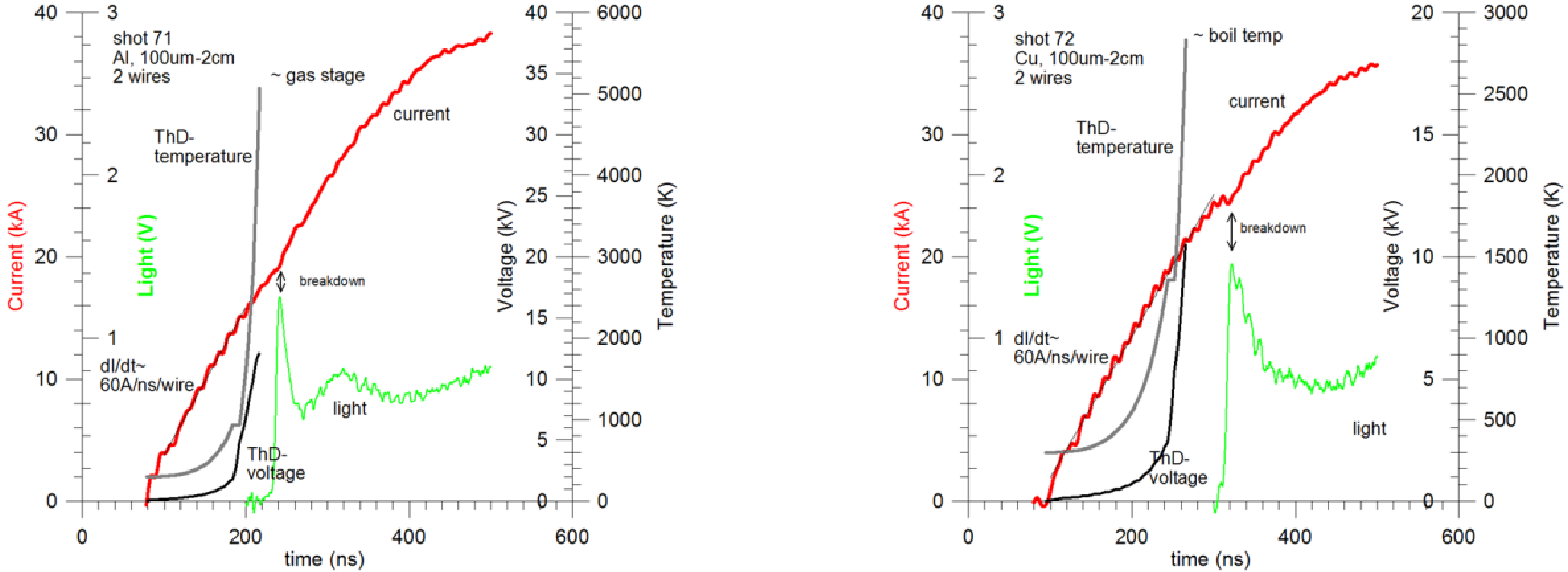
Lines of interest include:

- 121 nm – VUV
- 656 nm Visible

These are Lyman-alpha and Balmer-alpha transitions for the hydrogen atom, respectively. These transitions give us insight into energy transitions within the plasma and fundamental processes that are occurring. For instance, VUV photons are capable of photoionization events; they are involved in chemical reactions on surfaces, so they are important in understanding plasma formation and breakdown of surface contaminant desorption. VUV is difficult to characterize because the system must be in vacuum as this light can be absorbed in atmosphere (O2).

Through this experiment we will relate the relative number of visible and VUV photons in order to understand the temperature, density and velocity of the plasmas. This information will help in the overall characterization of the wire/foil plasmas.

Breakdown Dynamics in 100 micron Aluminum and Copper Fine Wires



Aluminum Wires **Copper Wires**

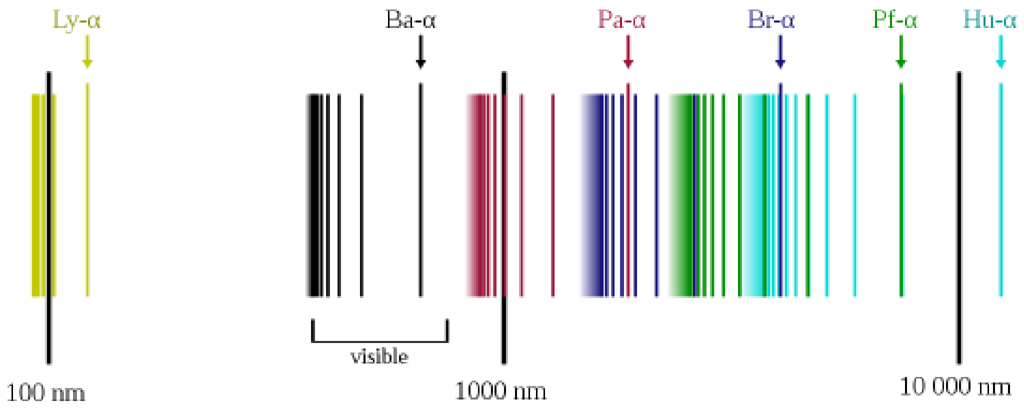
This is data from previous experiments using the wire pulser previously shown, they show light emission from copper and aluminum wires in the visible region. (The green traces on the graphs above show the signals from an unfiltered Si pin diode)

Experimental Results

The three possible outcomes that we could see are the following:

1. Differences in plasma initiation (breakdown) time between the visible and VUV wavelengths
2. VUV plasma breakdown occurs first
3. Visible light from plasma breakdown occurs first

The outcome of this experiment will give us information as to the intensity over specific wavelength ranges, and help to characterize the wire/foil plasmas.



References

- Vladimir I. Oreshkin and Rina B. Baksht, “Wire Explosions in Vacuum”, IEEE transactions on plasma science, vol. 48, no. 5, May 2020
- J. E. Bowers and Y. G. Wey, “High-Speed Photodetectors”, Department of Electrical and Computer Engineering, University of California
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- Theodor W. Hansch, Arthur L. Schawlow, and George W. Series; “The Spectrum of Atomic Hydrogen”, 1979 Scientific American, Inc.

Questions?