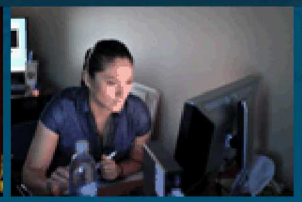
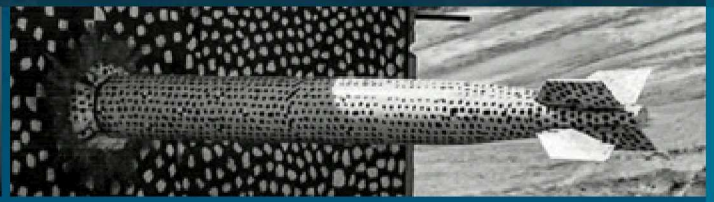
SAND2020-7818C

SEERI:
1688 Department Presentation





PRESENTED BY

Kyle James Swanson, University of Nevada, Reno

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Outline

- **BIO**
- **Project Working On/Details of Project**

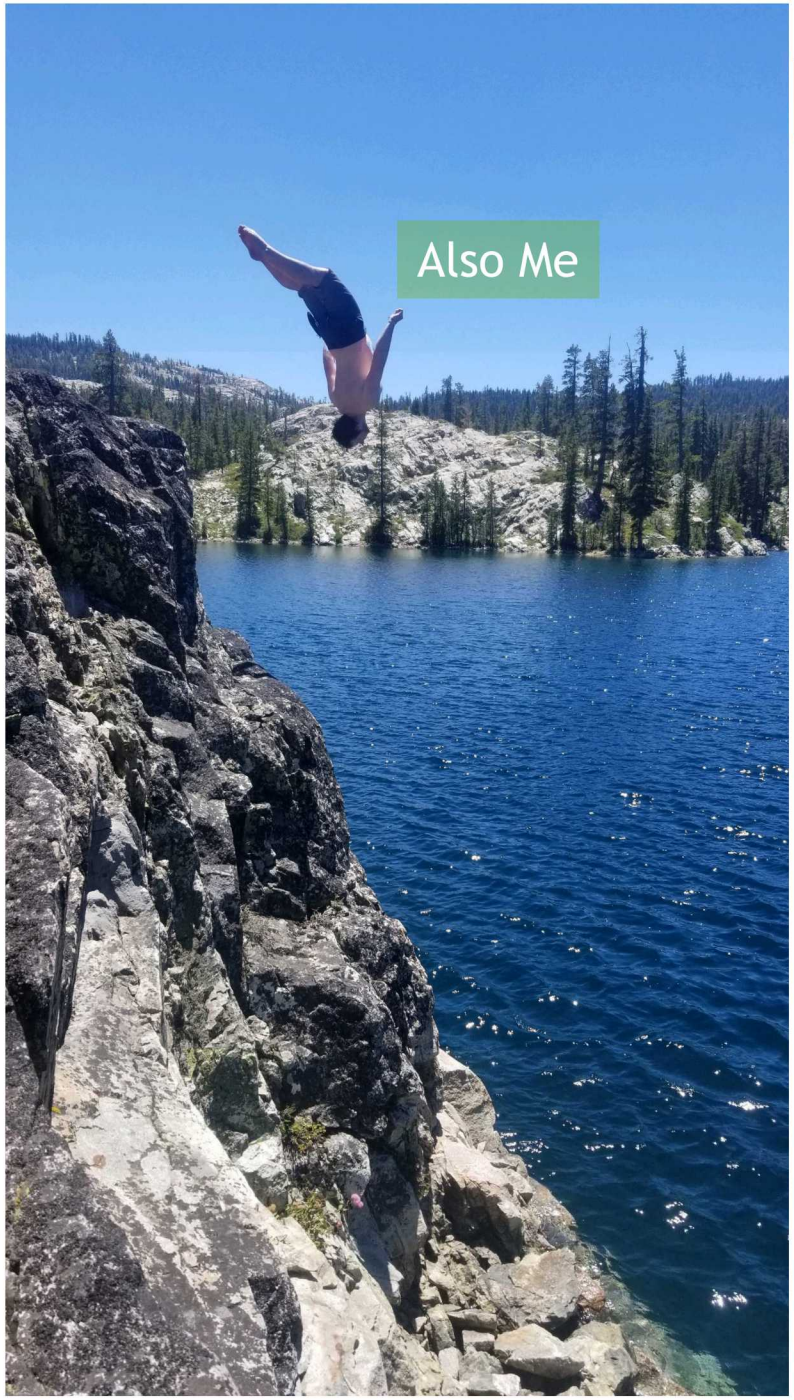
Kyle James Swanson

-On the way to adventure-

Hobbies:

Adventuring

- Kayaking
- Shredding the Gnarr
  - Snow/water
- Climbing



School: Physics department of the University of Nevada, Reno

Degree: PhD candidate in plasma and atomic physics with emphasis in experimental laboratory astrophysics.

Dissertation focus: Laboratory produced photoionized plasmas

Mentors: Vladimir V. Ivanov and Roberto C. Mancini

Organization: 1688 – Radiation Experiments

Manager: Brent Jones

Outline

- **BIO**
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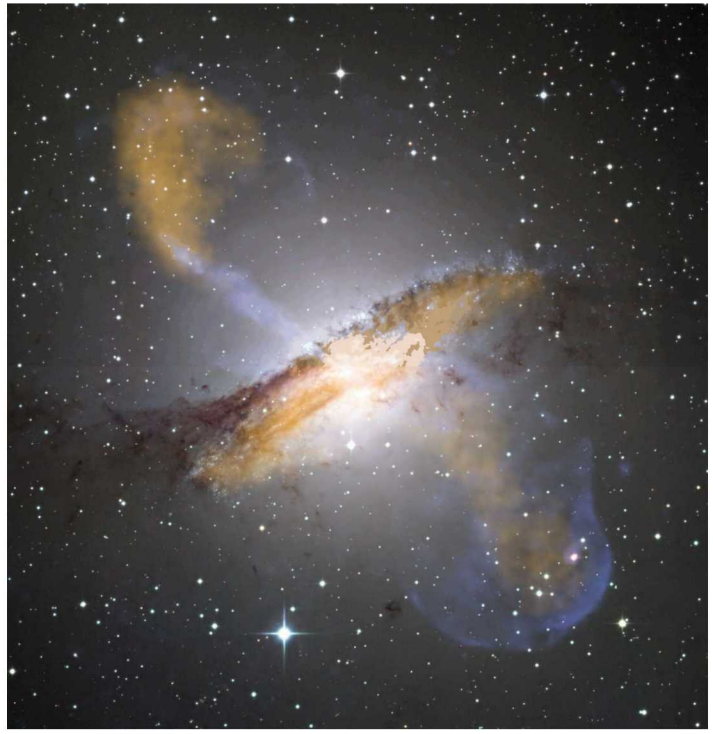
Photoionized Plasmas are Complex Systems in Astrophysical Environments

- Highly energetic astrophysical environments[1,2,3] are hosts to photoionized plasmas.
- A high-intensity broadband X-ray flux photoionizes surrounding gas.
- Data recorded with orbiting telescopes[1] are challenging to acquire and difficult to interpret[1,4].
- Atomic physics and radiation transport models are needed to interpret these observations.
- Controlled and reproducible laboratory experiments play a key role in the validation of photoionization models[4].

Centaurus A
Active Galactic Nucleus



ESO/WFI (Optical); MPIfR/ESO/APEX/A.Weiss et al. (Submillimetre); NASA/CXC/CfA/R.Kraft et al. (X-ray)

1) Miller et al. “The accretion disk wind in the black hole GRO j1655-40” The Astrophysical Journal (2008)
2) Murray et al. “Accretion disk winds from active galactic nuclei” The Astrophysical Journal (1995)
3) Jacoby et al. “The planetary nebula a39: An observational benchmark for numerical modeling of photoionized plasmas” The Astrophysical Journal (2001)
4) Mancini et al. “Accretion disk dynamics, photoionized plasmas, and stellar opacities” Physics of Plasmas (2009)

Why are Photoionized Plasmas Different from other Plasmas?

Photoionized plasmas are said to be "over-ionized"…

What is meant by this colloquialism?

- A photoionized plasma will have higher ionization than a collisionally ionized plasma with the same temperature.

Photoionized plasmas can be characterized by incident X-ray flux, atomic physics, and density.

The ionization parameter[1]: $\xi \propto \frac{I}{n_e}$

Ionization parameters $\gg 1\ erg\ cm\ s^{-1}$ are astrophysically relevant[2].

1) Tarter et al. "The Interaction of X-ray Sources With Optically Thin Environments" Astrophysical Journal (1969)
2) Bailey et al. "Neon Photoionization Experiments Driven by Z-pinch Radiation" Journal of Quantitative Spectroscopy and Radiative Transfer (2001).

Photoionized Neon Gas Cell Experiments on the Z Machine[1]

The implosion of a double-nested tungsten wire-array Z-pinch produces a broadband X-ray flux.

A cm-scale cell filled with neon gas is irradiated by the broadband X-ray flux.

How do we tune the ionization parameter?

We have two "knobs": X-ray flux and Density

$$\xi \propto \frac{I}{n_e}$$

X-ray flux

The gas cell is fielded at two different distances from the Z-pinch.

- Close position: 4.3 cm
- Far position: 5.9 cm
  - ~ Factor of 2 less than the close position

Density

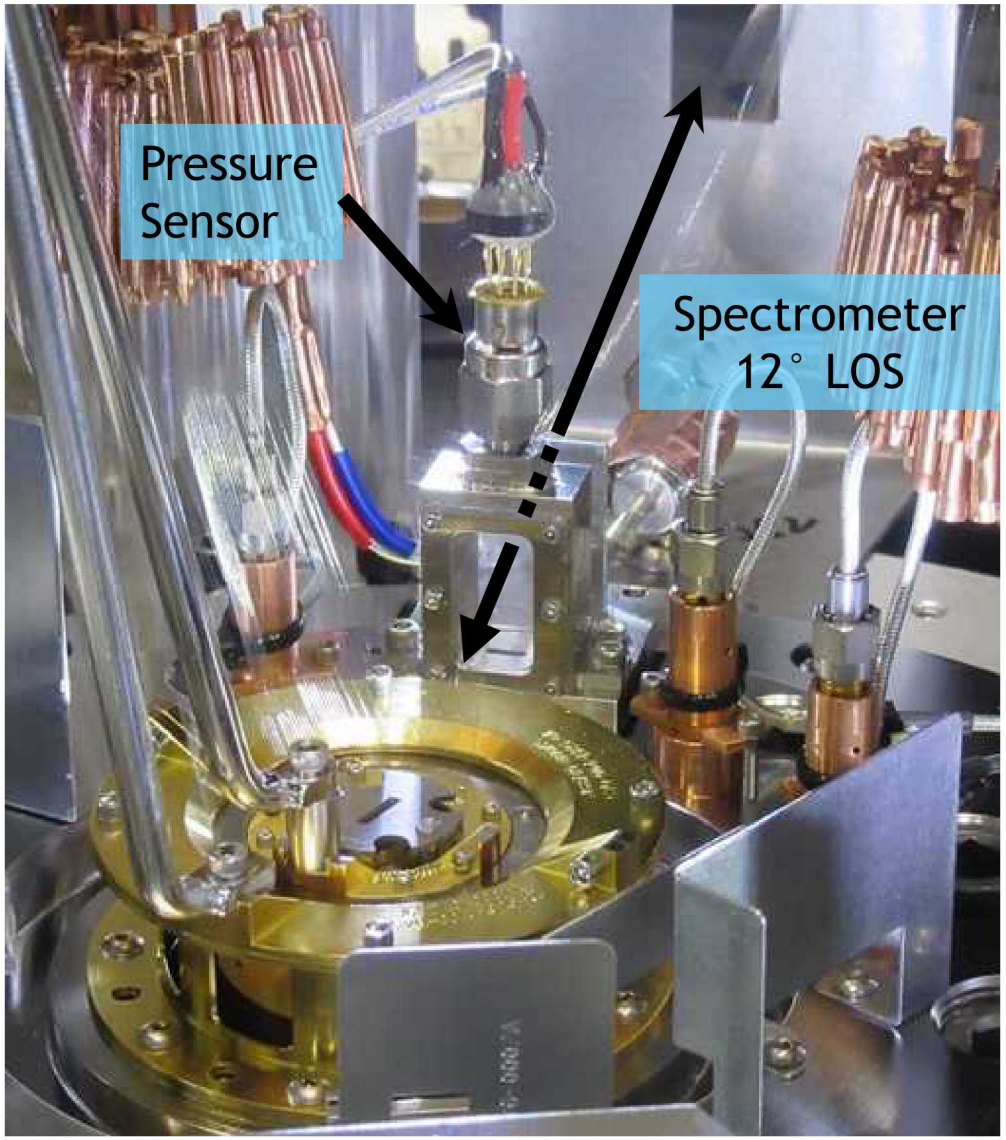
The atomic density of the gas cell is an adjustable parameter.

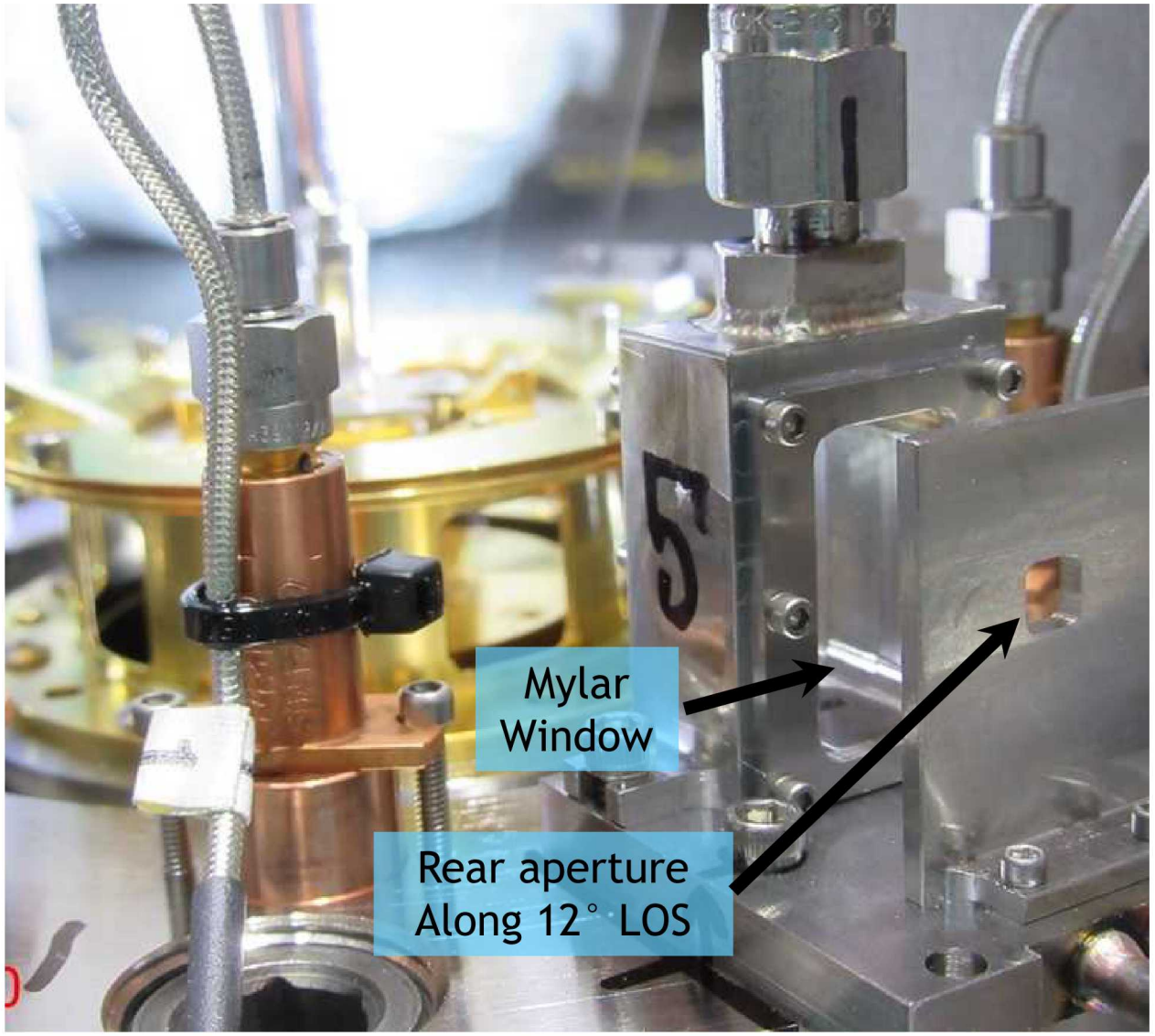
- ~ $10^{17} - 10^{18}$ cm^{-3}

Ionization parameters up to 60 erg cm/s have been measured[2]

1) Ian Hall et al. "Absorption Spectroscopy of a Laboratory Photoionized Plasma Experiments at Z" *Physics of Plasmas* (**2014**)
2) Mayes et al. "Neon photoionized plasma experiments at z and zebra" APS DPP Meeting (2019)

Photoionized Neon Gas Cell Experiments on the Z Machine

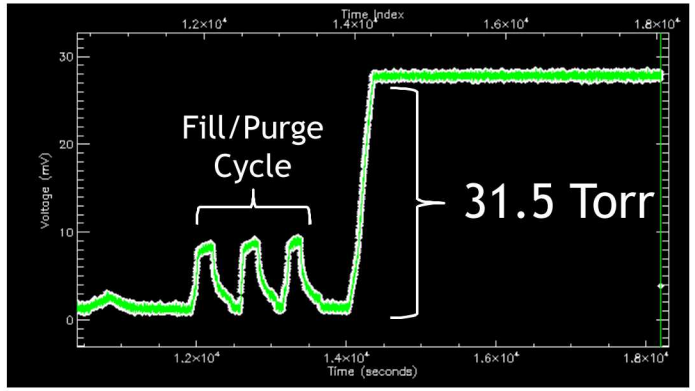




The Neon Plasma Is Diagnosed Via Two Diagnostics

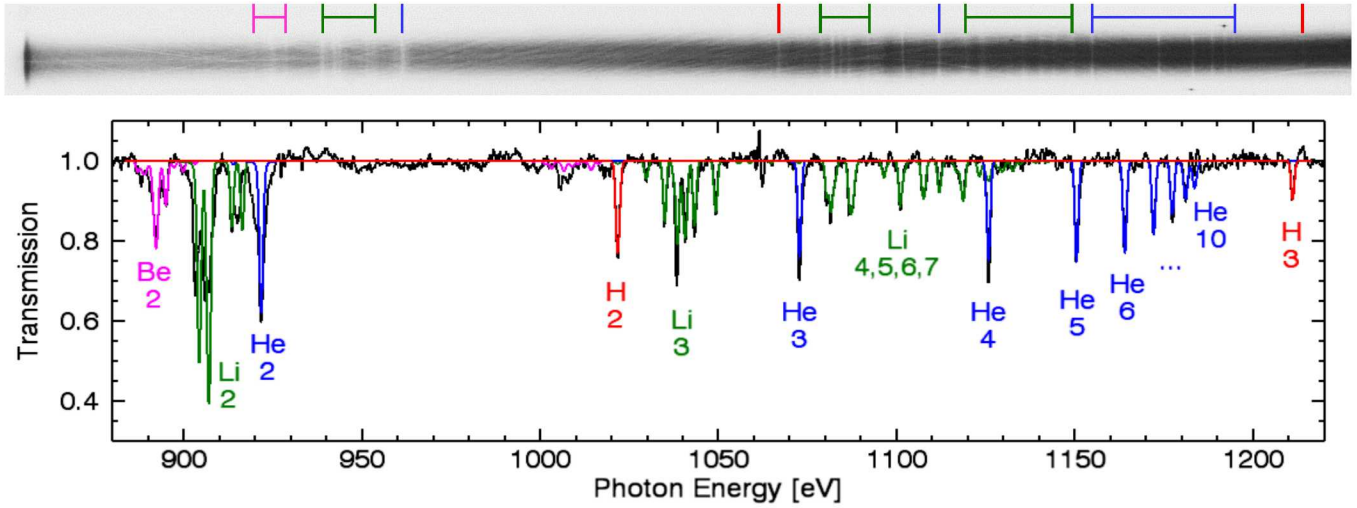
1. Atomic density

- Atomic density within the gas cell is monitored via a pressure transducer.



2. X-ray spectroscopy

- X-ray absorption spectroscopy is recorded with the TREX X-ray spectrometer.[1]
- Spectral range of interest is ~ 850-1250 eV.
- Observation of H-, He-, Li-, and Be-like ions show evidence of a highly charged neon plasma.[2]
- X-ray heating dynamics and electron temperature extracted from transmission spectroscopy.[3]



Future Diagnostic Capability: Plasma uniformity probe

Simulations predict a region of hydro-unperturbed neon plasma in the central region of the gas cell.

- A photon doppler velocimetry (PDV) diagnostic is currently being developed to probe the central region of the gas cell.

1) Lake et al. "Twin-elliptical-crystal time- and space-resolved soft x-ray spectrometer" Review of Scientific Instruments (2006)
2) Mayes et al. "Neon photoionized plasma experiments at z and zebra" APS DPP Meeting (2019)
3) Mancini et al. "X-ray heating and electron temperature of laboratory photoionized plasmas" *Physical Review E* (**2020**)

Questions?