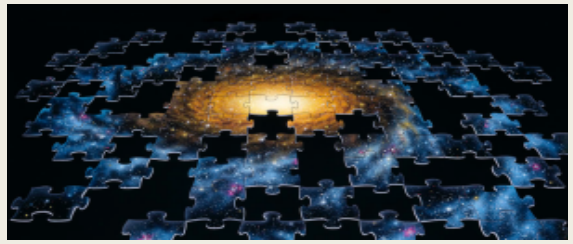
SAND2021-13911C

RECENT PROGRESS AT THE WCAPP



APS DPP

4 November 2021

Wootton **C**enter for **A**strophysical **P**lasma **P**roperties

University of Texas, University of Nevada Reno,

Sandia National Laboratories

Funded by NNSA through SSAAP DE-NA0003843

National Nuclear Security Administration

Sandia National Laboratories

U.S. DEPARTMENT OF ENERGY

Office of Science

NSF

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The scientific revolution in Astronomy:

Technologies like Z at SNL, NIF at LLNL, and Omega at LLE make possible *experiments under Cosmic Conditions*

EXAMPLES:

- Iron opacity in the interior of the Sun & Sun-like stars, Z
- New models of the Lunar origin, Z
- Experimental explorations of EoS under astrophysical conditions, NIF

Alan J. Wootton

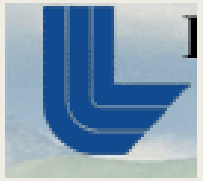
WCAPP also represents a collaboration among a large number of scientists from national labs and academia

J. Bailey, T. Nagayama, G. Loisel, G. Dunham, S. Hansen, G. Rochau, T. Gomez, Marc Shaeuble, M. Hess
Sandia National Laboratories

R. Mancini, V. Ivanov, G. Jaar, K. Swanson
University of Nevada – Reno

D. Winget, M. Montgomery, A. Wootton, B. Dunlap, D. Mayes, J. Wheeler, K. Hawkins, Patty Cho, Malia Kao, Jackson White, Bryce Hobbs **University of Texas – Austin**

I. Hubeny
University of Arizona



R. Heeter, R. Shepherd, D. Liedahl, C. Iglesias, B. Wilson,
Lawrence Livermore National Laboratory

C. Fontes, D. Kilcrease, T. Perry, D. Saumon
Los Alamos National Laboratory

J. MacFarlane, I. Golovkin
Prism Computational Sciences

T. Kallman
Nasa Goddard

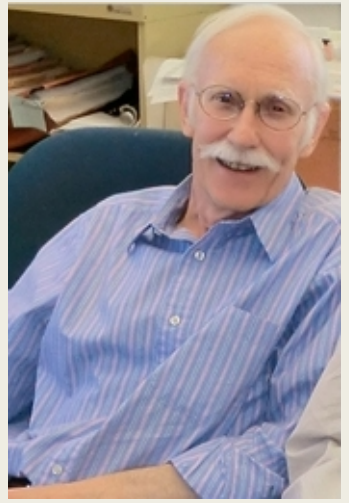
The WCAPP TEAM

The University Team

Don Winget

Roberto Mancini

Mike Montgomery



Craig Wheeler

Keith Hawkins

The WCAPP TEAM

The Postdoc Team

Bart Dunlap
UT

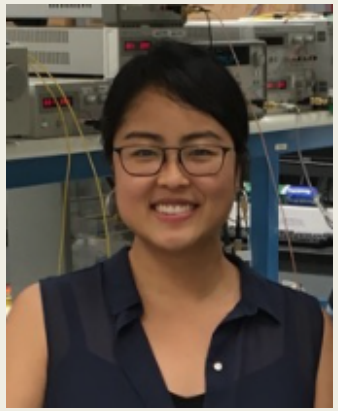
Dan Mayes
UT

Georges Jaar
UNR

The WCAPP TEAM

The Graduate Students Team

Senior Graduate Students



Patty Cho

Kyle Swanson

First-year Graduate Students

Bryce Hobbs

Malia Kao

Jackson White

The WCAPP TEAM

The Sandia Team

Jim Bailey

Greg Rochau

Guillaume Loisel

Tai Nagayama

Thomas Gomez

Stephanie Hansen

Mark Hess

The WCAPP TEAM

The NIF Team

Ted Perry

Bob Heeter

Ronnie Shepherd

Harry Robey, Evan Dodd, Kathy Opachich, Dan Kalantar, Rich Zacharias, Bruce Remington

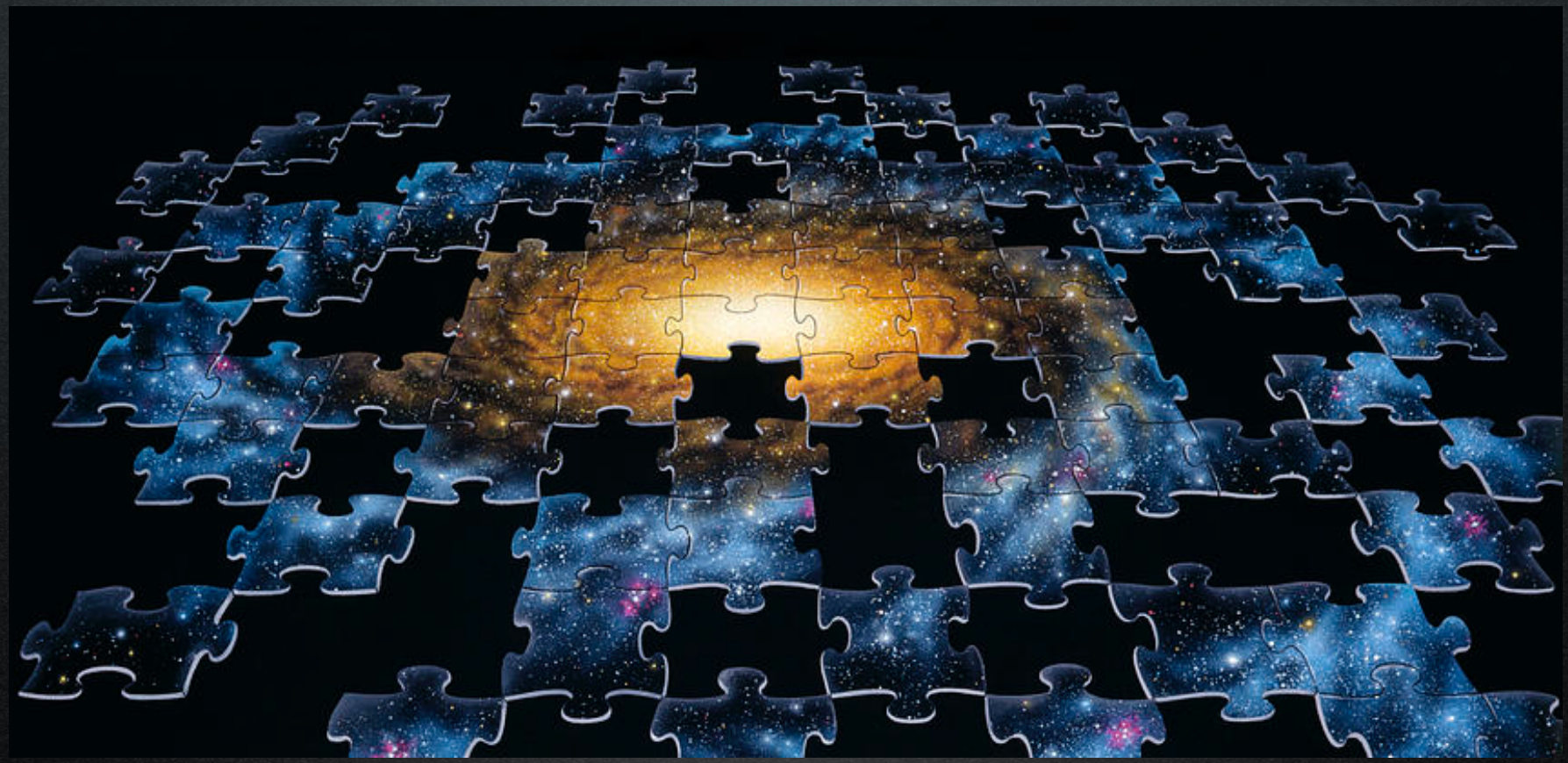
The WCAPP TEAM

The Numerical Experiments/Theory/Modeling Team

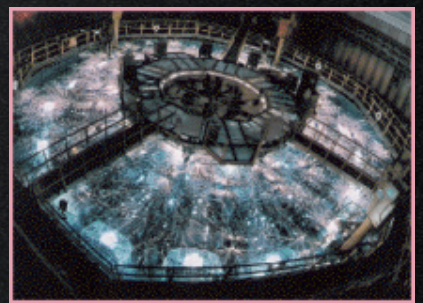
Chris Fontes, Dave Kilcrease, Mark Zammit, Didier Saumon
Los Alamos National Laboratories

Stephanie Hansen and Thomas Gomez
Sandia National Laboratories

In research you try to see the pattern even with missing pieces…



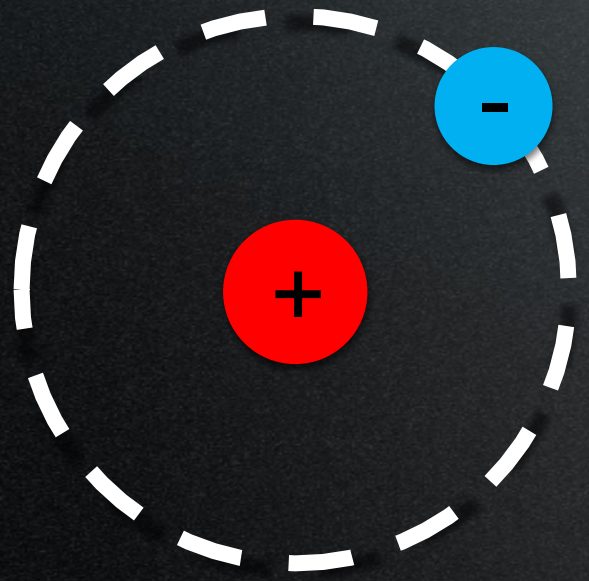
For us, some of the missing pieces are “missing physics,” the untested *Physics of Atoms*



“Atomic Physics is a Solved Problem”

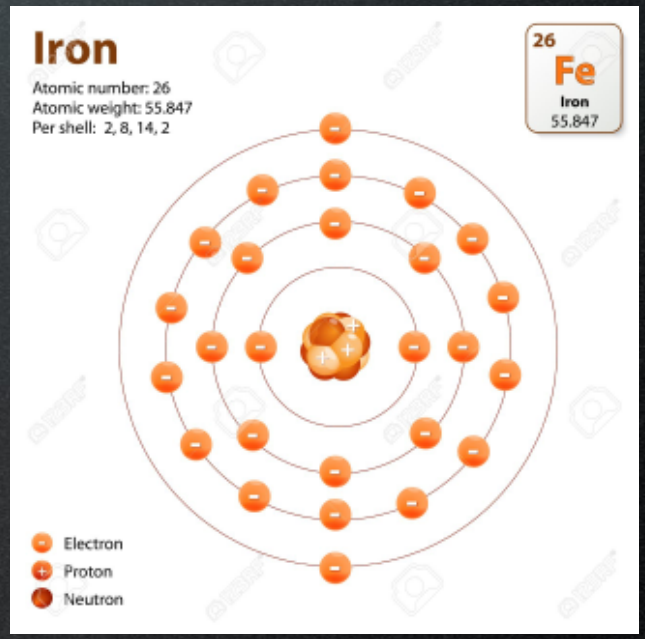
- anonymous string theorist

The hydrogen atom is the simplest atom, and is “completely understood”



Hydrogen atom

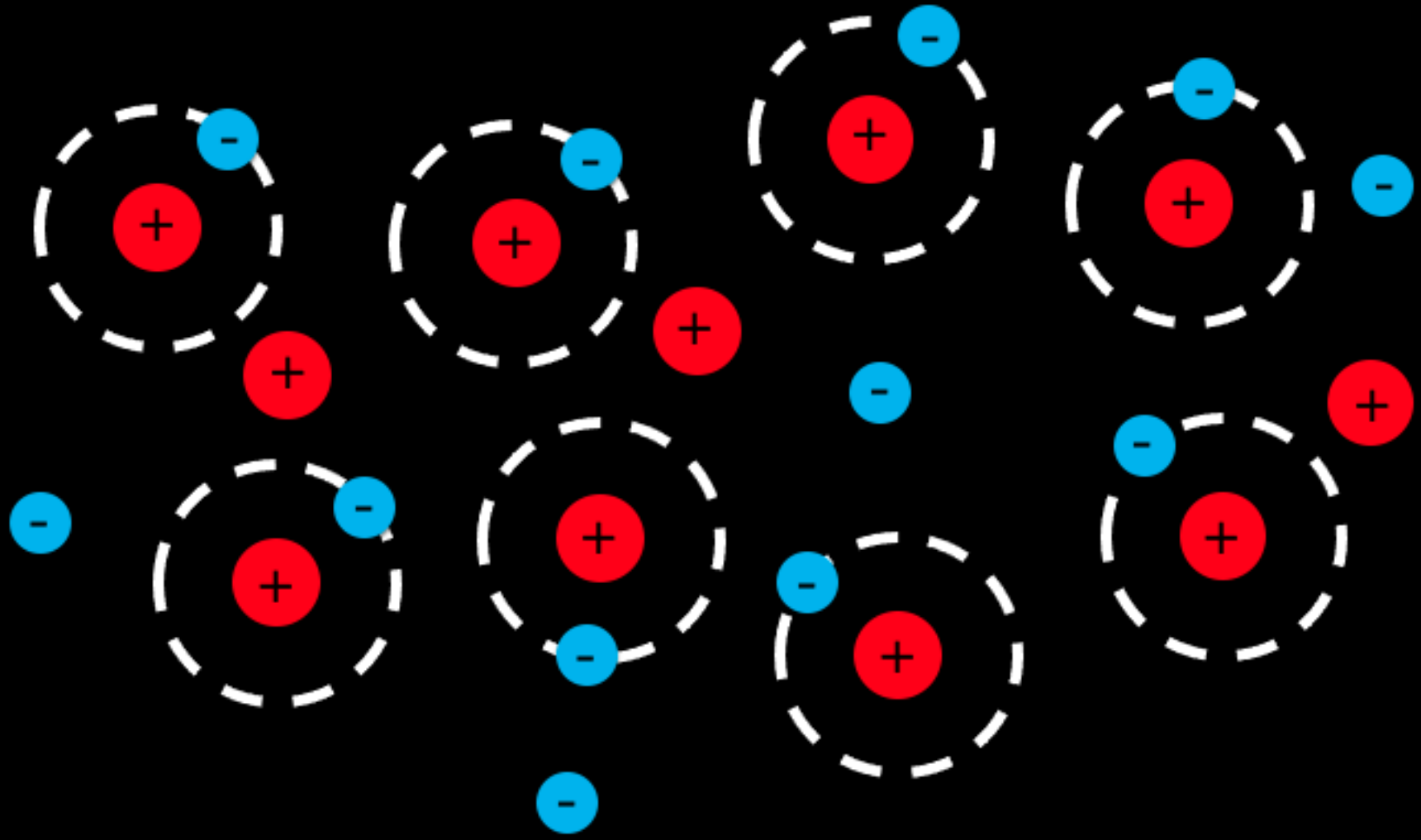
Other atoms are not as simple …or quite as well understood



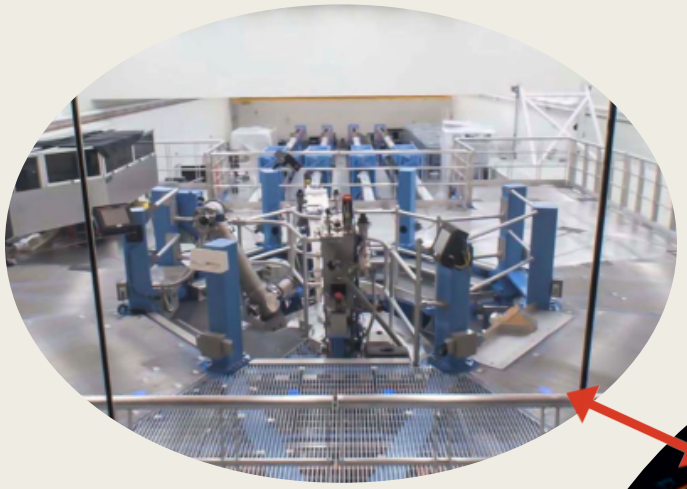
Clearly, a more difficult problem

Yet even “simple” atoms are never alone…

Nearby atoms, electrons, and ions affect each other:

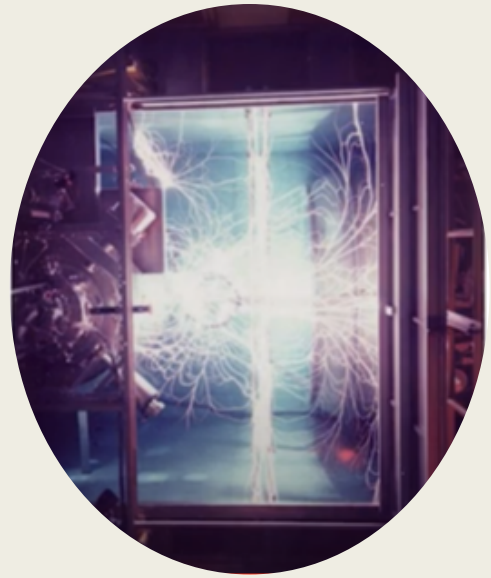


Theory and Numerical Experiments



OMEGA - LLE

The Z Machine - SNL



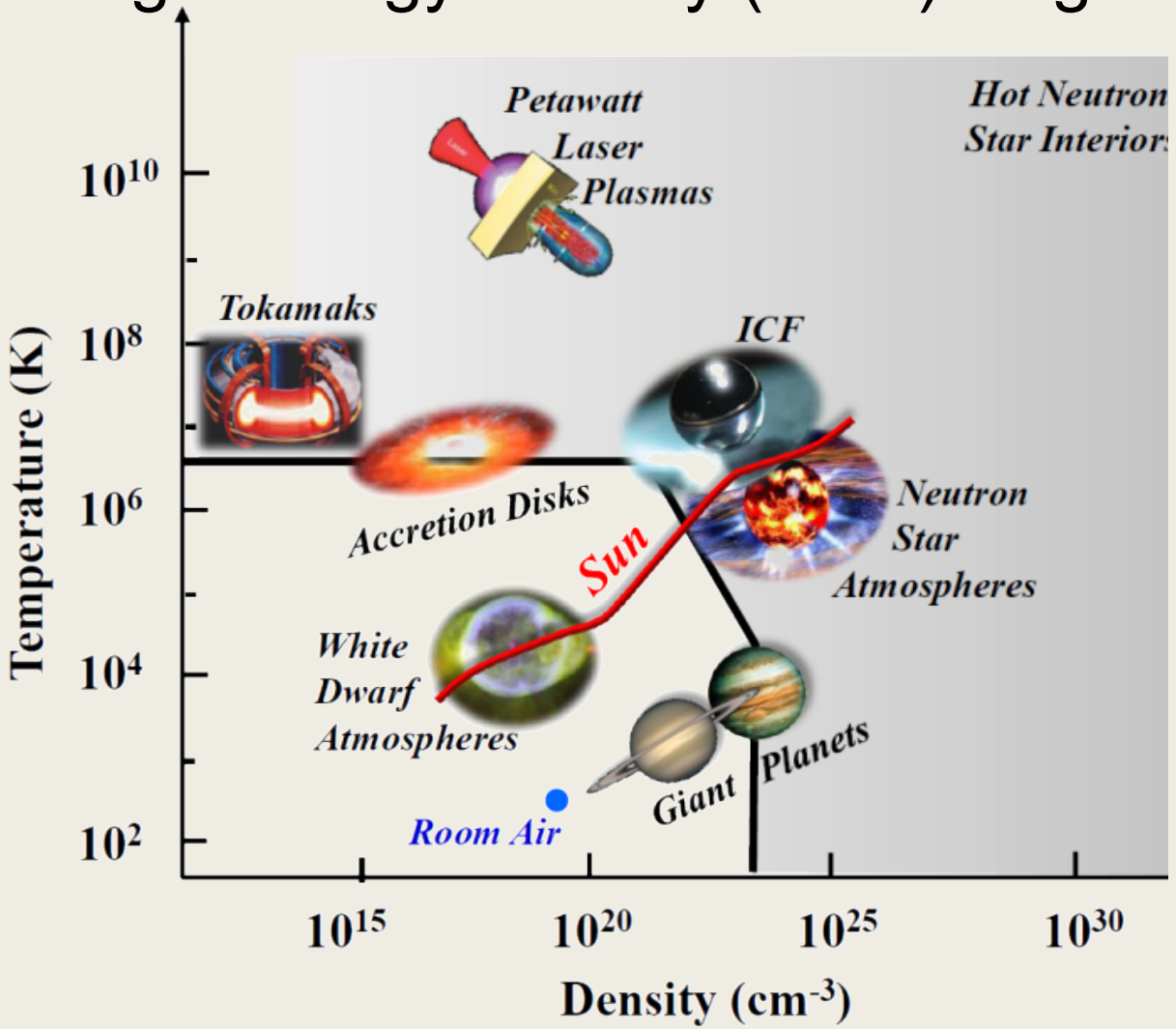
Zebra - UNR

NIF LLNL

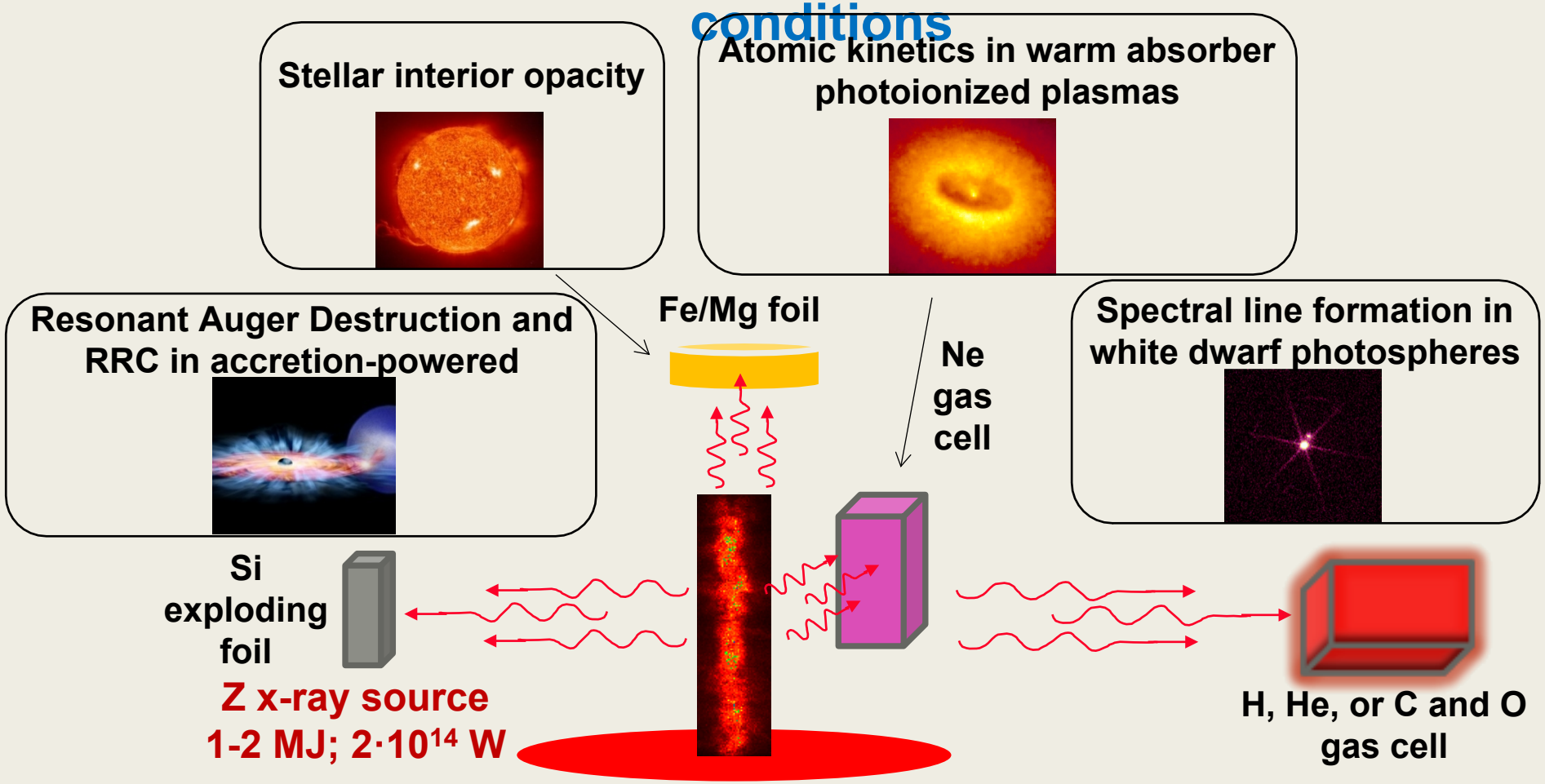
McDonald Observatory
Hobby-Eberly Telescope

Experiments now access a broad range of the energy-density phase space

High Energy Density (HED) Regime



WCAPP experiments on Z exploit megaJoules of x-rays to *simultaneously* address four separate astrophysics topics with experiments at astrophysical conditions



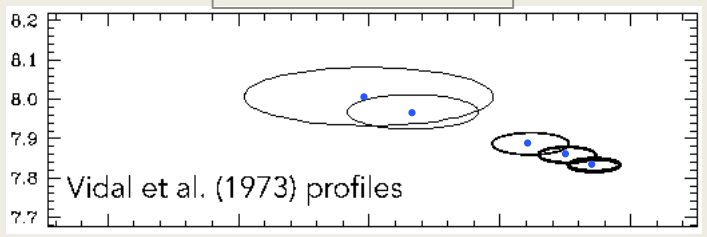
- Multiple samples are exposed to x-rays from Z on each shot
- Crucial for progress on oversubscribed MJ-class facility

Bonus" 5th experiment now in collaboration between WCAPP and CLA at UM!

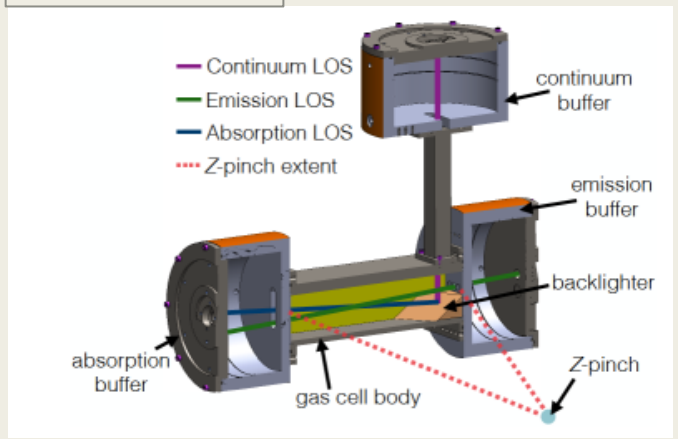
Example of Astrophysical Feedback: Coming Full Cycle

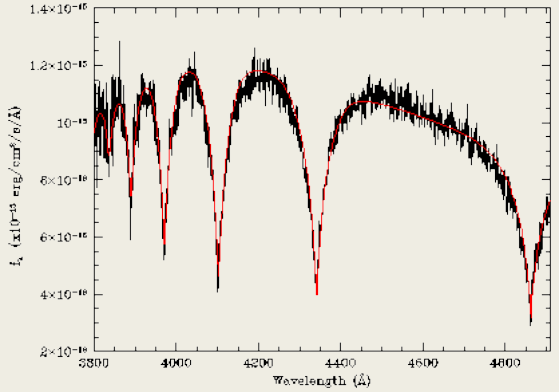
Patty Cho is leading an effort to insert new H Lyman and Balmer line profiles (from **Thomas Gomez**) into the model atmosphere code TLUSTY (**I. Hubeny,** U. of Arizona), and we're starting to explore the impact of these new model atmospheres on our inferences about white dwarf stars. Completing the cycle for determining the quantitative implications for astrophysics.

Improved Fits



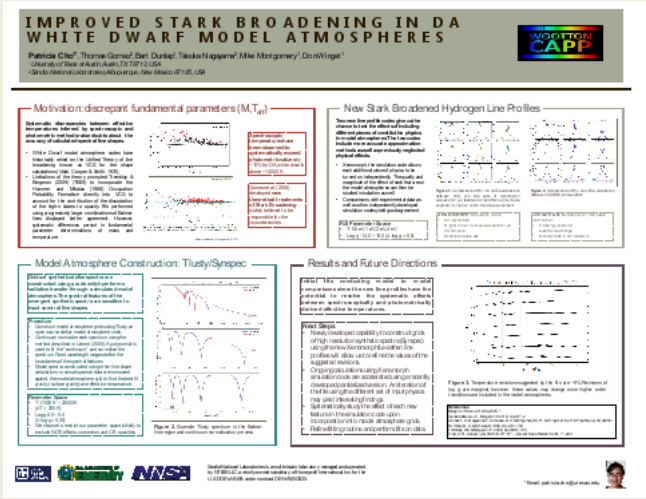
Experiments





Fits to observation

Improved Models

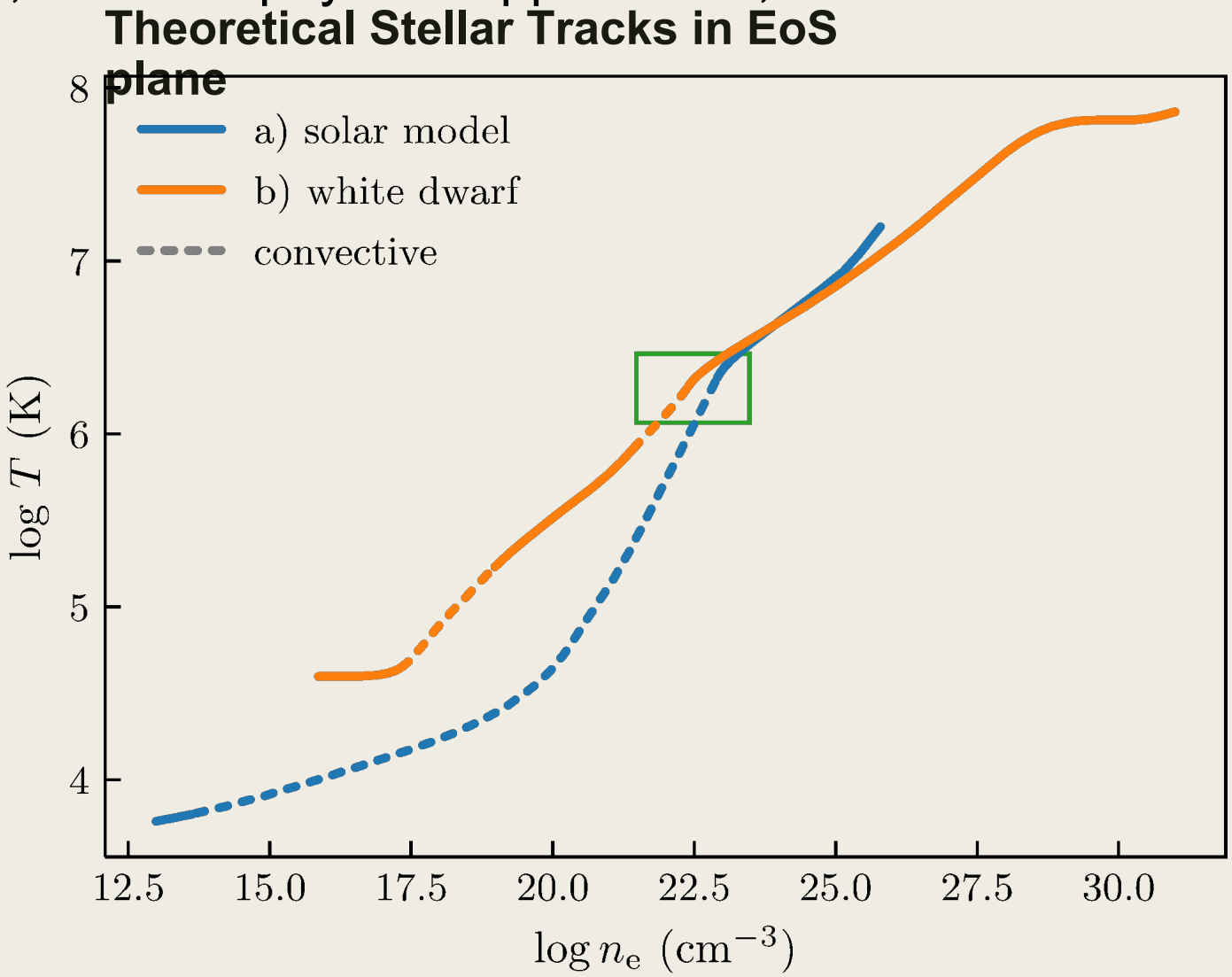


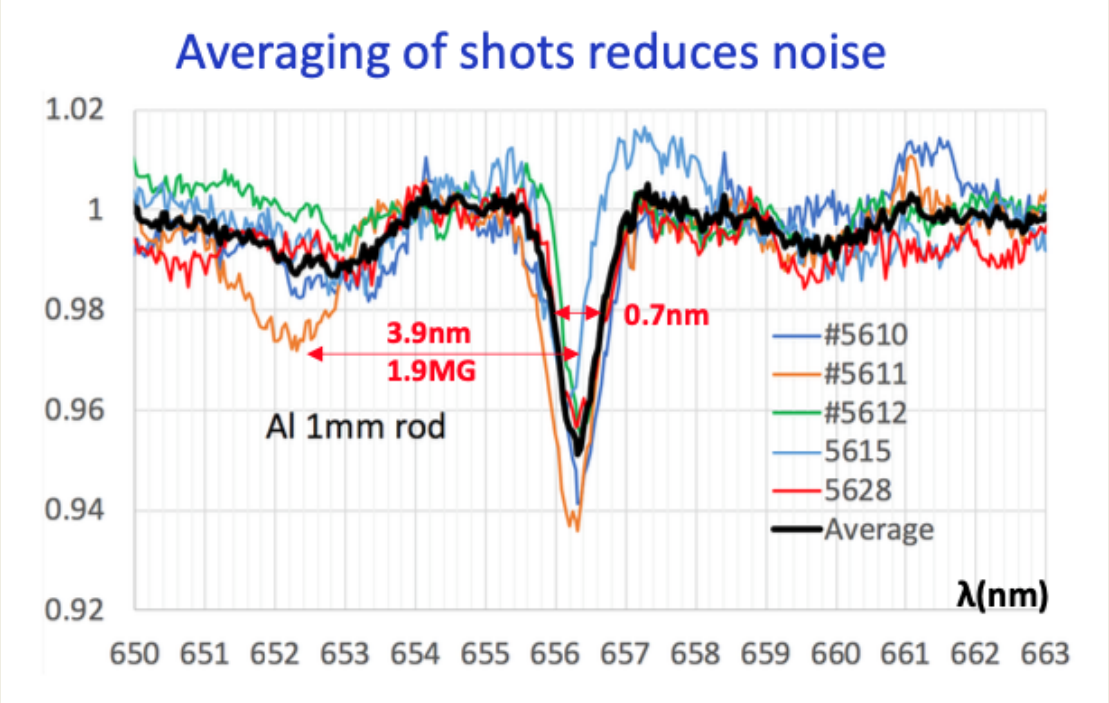
THE EVOLUTION OF WCAPP: POWERED BY ***SYNERGY***

- Reached critical mass in students and postdocs: word is getting out
- Bringing in students and postdocs with complementary skills/interests
- Human Synergy: students and postdocs linking projects
- Scientific Synergy: e.g., WDs and Main Sequence stars, Z and NIF

***SYNERGY**: the Ultimate 2 for 1 deal*. Important O opacities are in the same location in EOS plane for white dwarfs AND solar-type stars, AND we have Experiments on Z and NIF:

two platforms, two astrophysical applications; we can cross-calibrate platforms.





A shift of **σ**-wings indicates a 1.9MG B-field. It's in agreement with measurements from current and and the plasma size.

A width of the central peak is 0.7nm. It includes resolution, thermal, and quadratic Zeeman broadening.

Another way of thinking Full Cycle!

Thanks!

WOOTTON CAPP