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HIFSNews

Workshop on Accelerator-Driven Warm-Dense-Matter Physics

On February 22-24, 2006 the Heavy Ion Fusion Science Virtual National Laboratory (HIFS VNL) and UC/LLNL's Institute for Laser Science and Applications cohosted a Workshop on Accelerator-Driven Warm-Dense-Matter (WDM) Physics, held in Pleasanton, CA. The workshop drew together a diverse set of approximately 70 scientists from around the world including Germany (GSI and the Phillips University of Marburg), Japan (University of Electrocommunication), six US Laboratories (Lawrence Berkeley National Laboratory (LBNL), Lawrence Livermore National Laboratory, (LLNL), Princeton Plasma Physics Laboratory (PPPL), Sandia National Laboratory (SNL), Los Alamos National Laboratory (LANL), and Stanford Linear Accelerator (SLAC)), three private corporations (Tech-X, SAIC, Voss Scientific) and several US universities (including Berkeley, Princeton, and Washington State University).

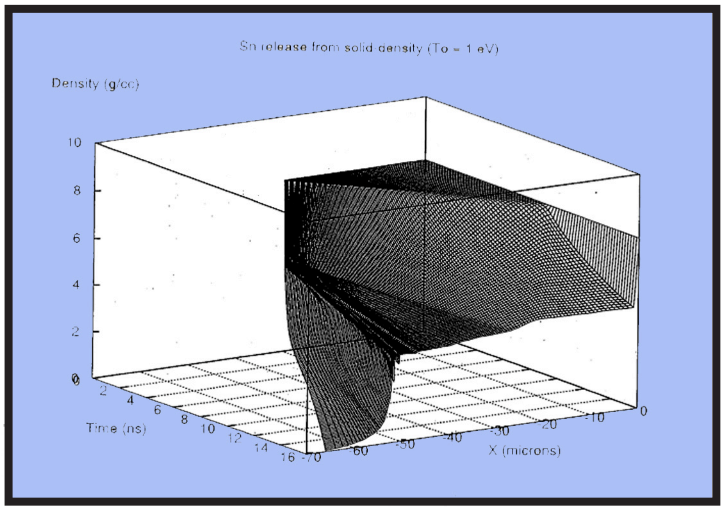
The field of warm dense matter requires coordination among a diverse set of scientific disciplines and many were represented at the workshop. The disciplines included: accelerator physics, laser physics, pulse power physics, equation of state, ion stopping, the physics of liquid metals, hydrodynamics, target physics, and computational physics. The meeting location in Pleasanton was chosen to encourage scientists from across LLNL's various programs that have some connection to warm dense matter to attend, and indeed some 22 scientists from LLNL attended.

The workshop consisted of plenary talks, a panel discussion on computational issues for the WDM regime, working group meetings, and reports from the working groups on the final day. The topics of the four working groups were: drivers and experiments; science and applications; diagnostics; and codes. The talks and working group reports are available at the workshop website, http://ilsa.llnl.gov/wdm, under the tab "Proceedings."

A previous Accelerator Driven High Energy Density Workshop held at LBNL, October 26-29, 2004, http://hifweb.lbl.gov/public/hedpworkshop/toc.html) focused more on the acceleration methods for creating warm dense matter conditions.

In this latest workshop, there was more of a concentration on the science itself, the WDM experiments and diagnostics, and the computational tools needed to simulate WDM experiments. For example, two talks were presented on Molecular Dynamics simulation approaches; one on simulating the equation of state using a quantum molecular dynamics approach and the other on ion stopping in the WDM regime. Another talk discussed the relation of the transport properties of liquid metals such as mercury and the connection to WDM materials. The unsolved questions and complexity of the WDM regime was elaborated upon in another talk. Figure 1 shows an example of hydrodynamic flow in the two-phase regime illustrating one example of the rich physics to be explored.

Diagnostics from a variety of driver experiments were discussed: several X-ray based techniques (including spectral and diffractive measurements), optical emission, electrical conductivity, measurements of the hydrodynamic expansion, measurements of ion dE/dX and ion charge state, and measurements of reflection and absorption coefficients.



Potential accelerator based experiments were reviewed including, near Bragg peak HIFS VNL experiments at ~0.2 to 1 MeV, GSI experiments at ~0.4 - 3 GeV/nucleon, electron experiments on ETA II at 5 MeV, and even possibly proton experiments at LANL at 0.8 GeV/nucleon.

The panel discussion on computer codes addressed what improvements in current codes (such as equation of state and ion stopping) are needed. The working group on computer codes created a useful taxonomy of the wide variety of codes that attack particular aspects of the WDM problem.

Various methods for producing WDM were discussed. The working group on drivers and experiments started to elucidate the pros and cons of various drivers. In particular, factors such as the precise control and uniformity of energy deposition, large

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sample sizes compared to diagnostic resolution volumes, ability to heat a wide variety of target materials (including both conductors and insulators), relatively long times to allow equilibrium conditions to be achieved, a benign environment for diagnostics, high shot rates, and good facility access, are all factors favorable for accelerators. However, the conclusion of the working group was that there are many methods for creating WDM conditions, and none are perfect, but the field will be advanced and is well served by comparing data from a number of different methods that overlap in a large, multidimensional parameter space.

Finally, the working group on WDM science and applications categorized the important questions that will be addressed by accelerator-based WDM. One important conclusion of that group was that the WDM regime should be defined by the physics rather than simple parameter choices. In particular, experiments will explore the dynamics of phase transitions; large changes in electronic structures; multi-phase states; and when complexities are compounded (e.g. when strong coupling and electron degeneracy are occuring simultaneously).

This workshop represents the second of what we expect will be a continuing series to highlight progress in this emerging and dynamic field.

~ John Barnard