Working Group on Science and Applications

Workshop on accelerator Driven Warm Dense Matter Physics

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Working Group on Science and Applications: Overview

- Group was to address the following questions:
  - What are the most important questions to be answered
  - What Applications will be effected
- 1st we discussed the nature of the Heavy Ion Beam position relative to other methods
  - Gas guns touch the bottom of the WDM phase space
  - HE touch the bottom of the WDM phase space
  - Initially we account for fact that HIBs will be in a similar situation and discuss accordingly
- These considerations imply a need to choose objectives that both get one to the regime of interest *and* do it uniquely

What is relevant WDM science for HIBs? Definitions

- The "official" definitions do not reveal underlying physical processes of importance
  - Energy density: U ~ 10^{11} J/m^3
  - Upper limit for plasma-like systems: $\Gamma > 1$
  - Lower limit for solid-like systems: $T \geq T_{fermi}$

Energy Density Parameter (u) Corresponding to ~10^{11} J/m^3	Value
Pressure	1 Mbar
Electromagnetic Radiation	
Electromagnetic wave (laser) intensity I (p~I)	3x10^{15} W/cm^2
Blackbody radiation temperature T (p~$T^{1/4}$)	5x10^6 K (400 eV)
Electric field strength E (p~E^2)	1.5x10^{11} V/m
Magnetic field strength B (p~B^2)	5.0x10^2 T
Particle Beams	
Current density (J) for a beam of 30 GeV electrons	1.0x10^5 A/cm^2
Current density for a beam of 100 MeV ions ($m=10m_p$, Z=1)	4.0x10^6 A/cm^2
Plasma Pressure	
Plasma density (n) for a temperature (T) of 1 keV (p~nT)	6x10^{20} cm^{-3}
Plasma density (n) for a temperature (T) of 1 GeV (p~nT)	6x10^{14} cm^{-3}
Ablation Pressure	
Laser Intensity (I) at 1μm wavelength (λ) (p~$(I/\lambda)^{2/3}$)	4x10^{12} W/cm^2
Blackbody radiation temperature T (p~$T^{3.5}$)	9x10^5 K (75 eV)

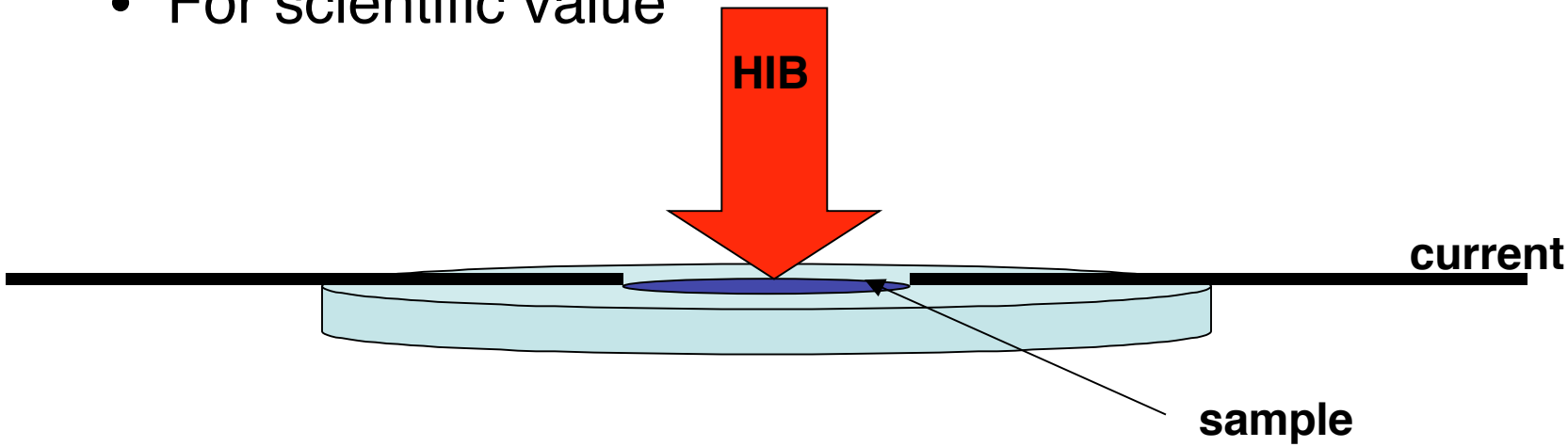
Simple definition allows broad interpretation

Redefinition necessary to frame science of interest to HIBs

- Since HIBs will ***start*** at low temperature end
- Redefine in terms of the physical processes making WDM intriguing and challenging
  - When Dynamics of Phase Transitions
  - When Large changes in the electronic structure
  - When multiple phases dynamically occur in HED
  - When complexities are compounded:
    - For example, strong coupling *together with* partial degeneracy make things difficult
- These processes can now be mapped directly on to experiments

Experiments of interest and a plan:

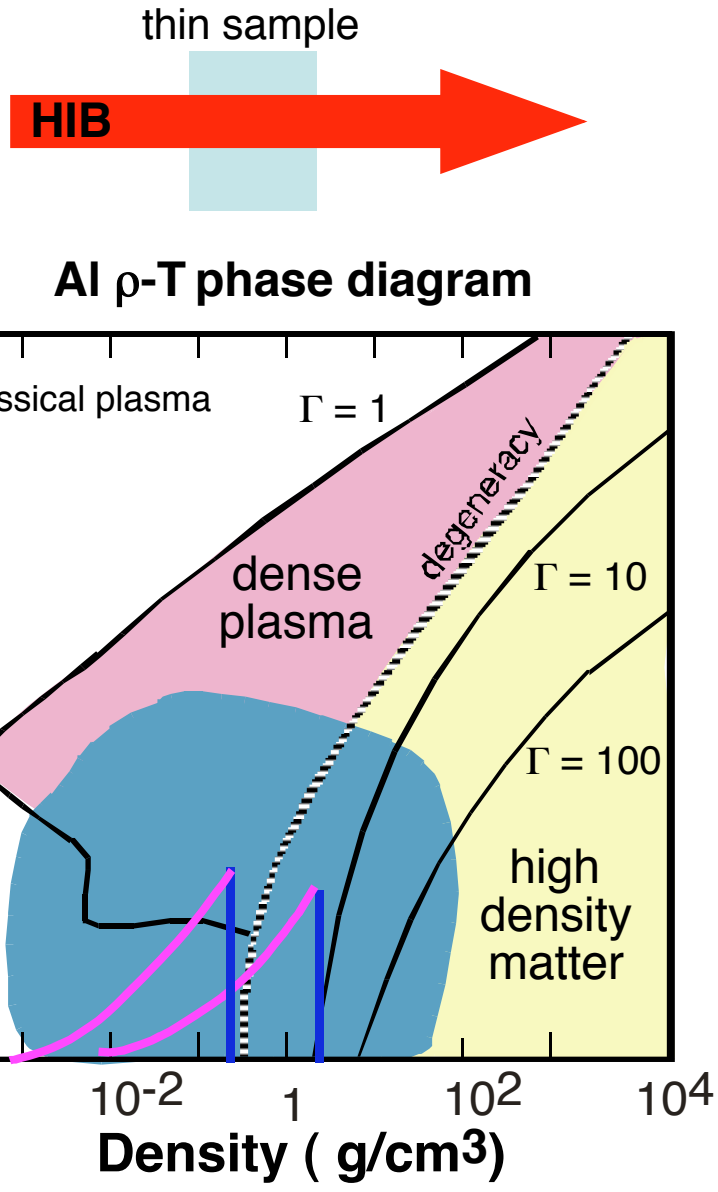
- HIB unique feature is volumetric heating
- Must include extensions to future experiments
  - 1st experiment should be as simple to field as possible and still provide important results
    - For operation of the HIB experiments
    - For scientific value



  - HIB interacts with a sample changing its conductivity probe using electrical measurements

Isochoric heating of foams yields important data and accesses two-phase region

- Straightforward and provides extension to future HIB capabilities
- HIB heats matter **uniformly** to create:
  - Isochores (constant ρ)
  - Isentropes (constant entropy)
- Underdense foams allows more complete sampling
  - Isochores (constant ρ)
  - Isentropes (constant entropy)



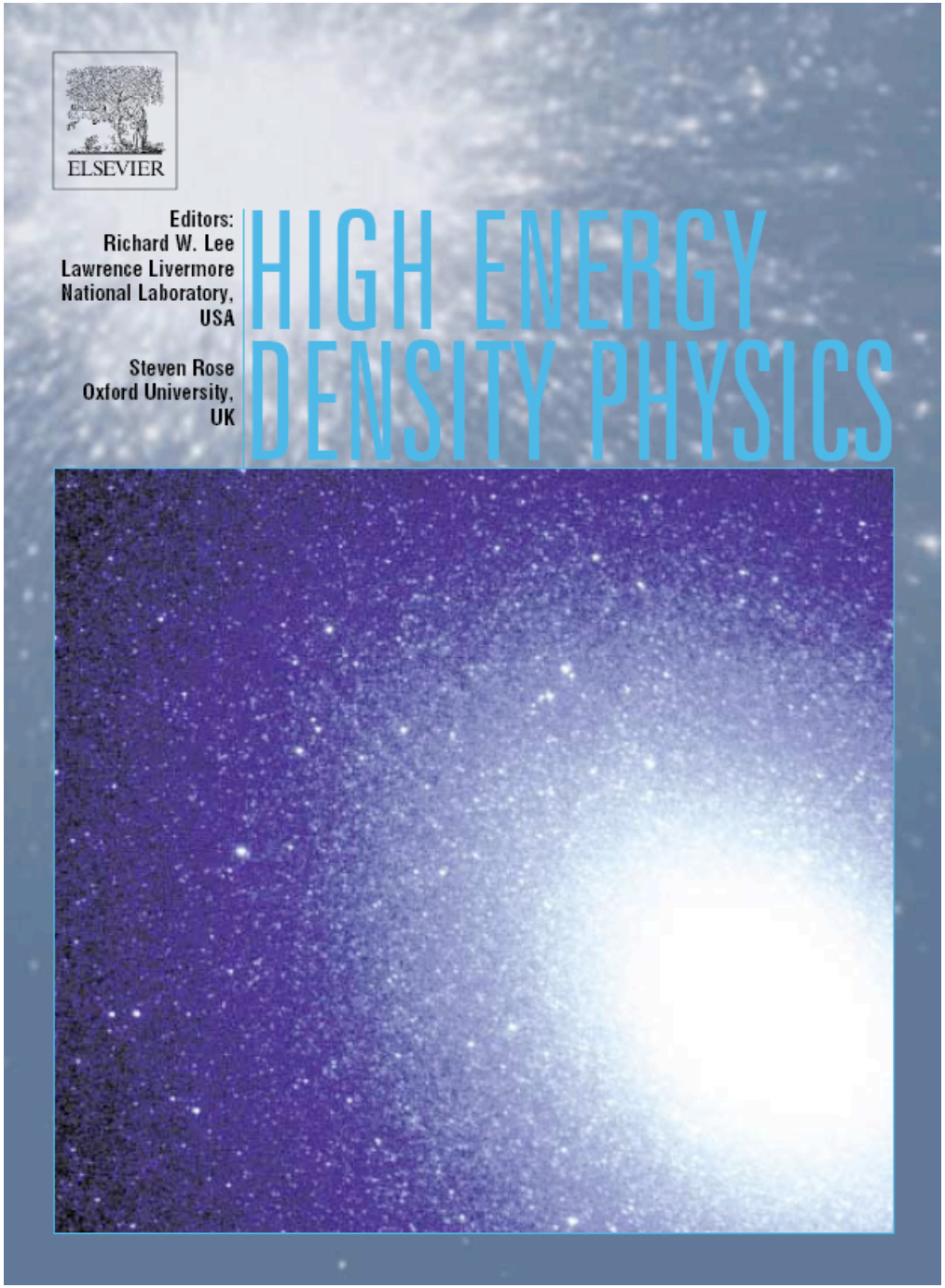
Experiments providing more coverage of other scientific areas

- Perform HIB heating on samples with mixtures of high Z and low Z, e.g.,
  - Accesses regime of interest for astrophysical problems
- Provide $\Delta E/\Delta X$ measurements on HIB samples
  - Measure the incident and transmitted beams in detail
  - Once developed use as a diagnostic for local conditions
- Create Ion-Ion plasmas
  - Seen in Br and I samples
  - Same as electro-negative plasmas
- Heating ferromagnetic materials with ns HIBs
  - Look for change of spin order…

Future experiments with expanded, extended HIB capabilities

- Primary goal would be to develop the creation of large volumes of uniformly heated WDM
  - Diagnostic complement would become highly refined

- At high T limit of the WDM phase space one would requires means to create plasma that are simultaneously strongly coupled and partial degenerate
  - Development of this capability due to uniform heating will be very important



High Energy Density Physics:

An international journal covering original experimental and related theoretical work studying the physics of matter and radiation under extreme conditions. 'High energy density' is understood to be an energy density exceeding about 10^{11} J/m^3. The editors and the publisher are committed to provide this fast-growing community with a dedicated high quality channel to distribute their original findings. Papers suitable for publication in this journal cover topics in both the **warm and hot dense matter regimes**, such as laboratory studies relevant to non-LTE kinetics at extreme conditions, planetary interiors, astrophysical phenomena, inertial fusion, and quark-gluon plasmas and includes studies of, for example, material properties and both stable and unstable hydrodynamics. Developments in associated theoretical areas, for example the modeling of strongly coupled, partially degenerate and relativistic plasmas, will also be covered.

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