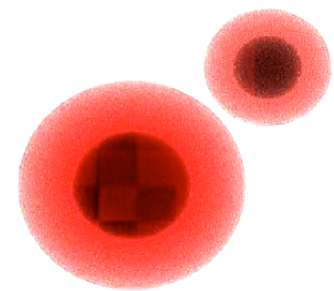
Date 07/30/2011

IHEDS Planetary break-out 2011

Ao, Davis, Hamel, Jacobsen, Kraus, Mattsson, Nettelmann, Remo, Saumon, Shulenburger

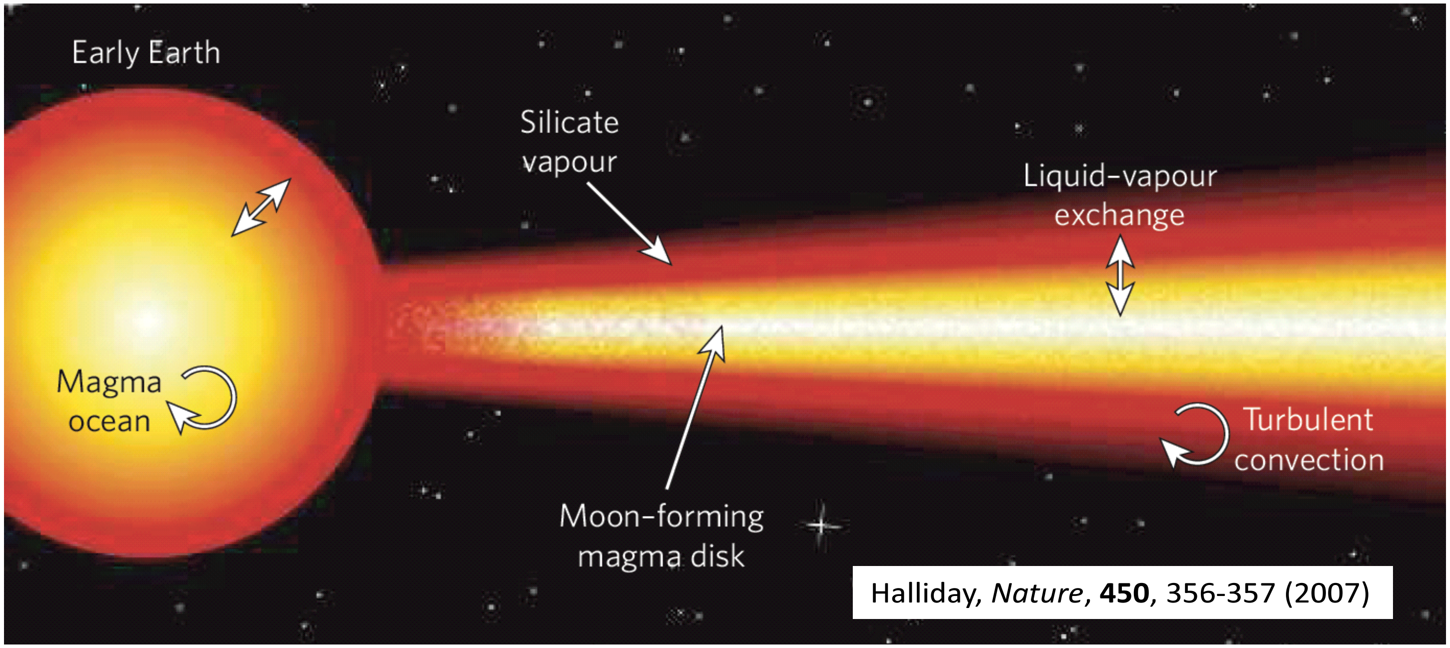
Intriguing physics of earth and super-earth materials and events, laboratory work crucial to gain understanding

- **Moon Forming Event**
  - **Moon would most easily be formed by the impactor**
  - **Earth and moon has virtually identical isotope composition**
  - ***Significant problem***
  - ***Critical point of silicates***
    - **Amount of rock vapor during MFE**



Metals (black) silicates (red) (Stein Jacobsen)

An extended vapor-liquid coexistence after MFE can explain the isotope equilibration between earth and moon



Halliday, *Nature*, **450**, 356-357 (2007)

Pahlevan & Stevenson (2007) proposed a model of ***isotopic equilibration of a magma disk derived from the Earth's impactor and the Earth*** through turbulent exchange in a relatively long-lived (for ~100-1000 years) silicate atmosphere enveloping both the Earth and the magma disk after the giant impact .

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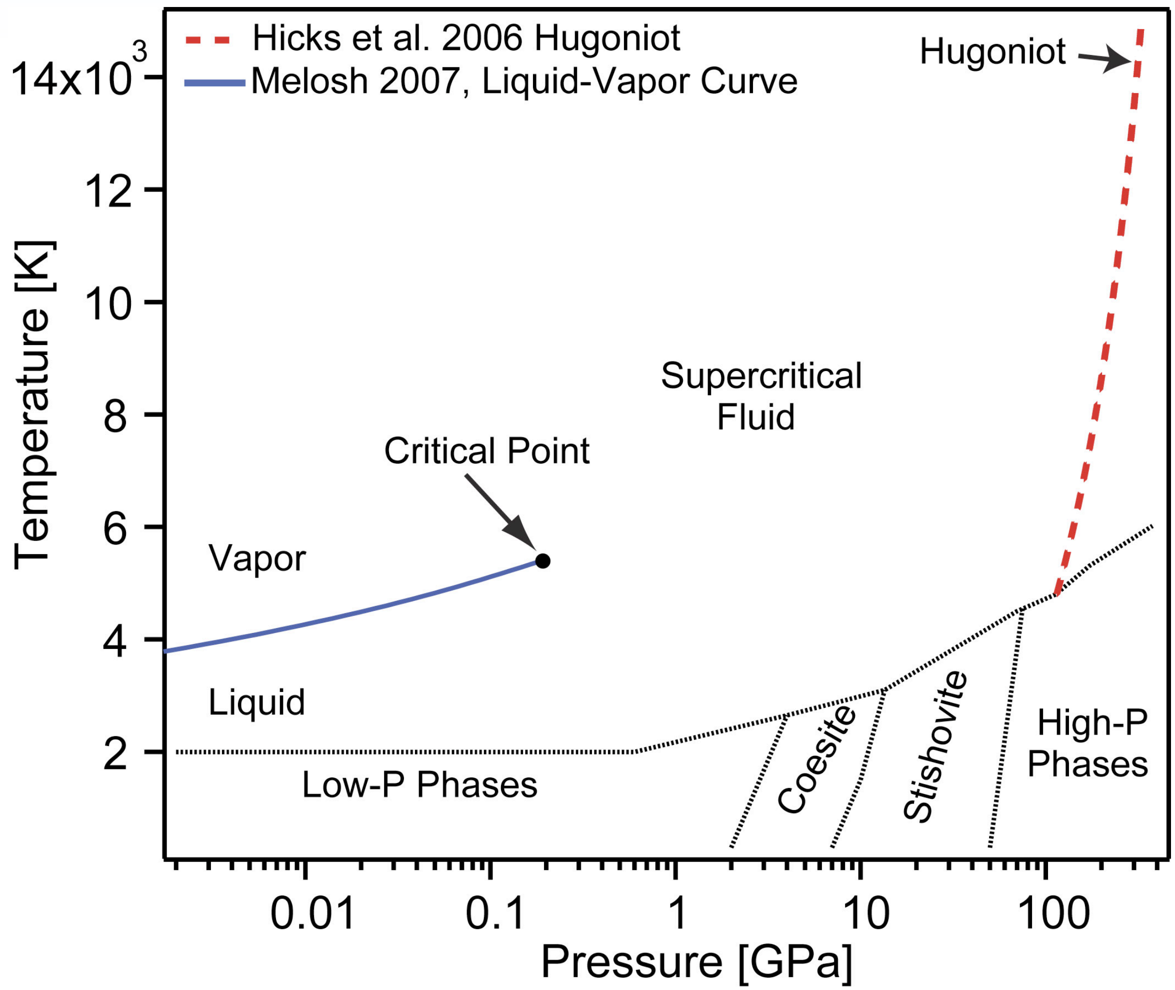
Accurate modeling relies upon knowing the vapor-liquid critical point of silicates



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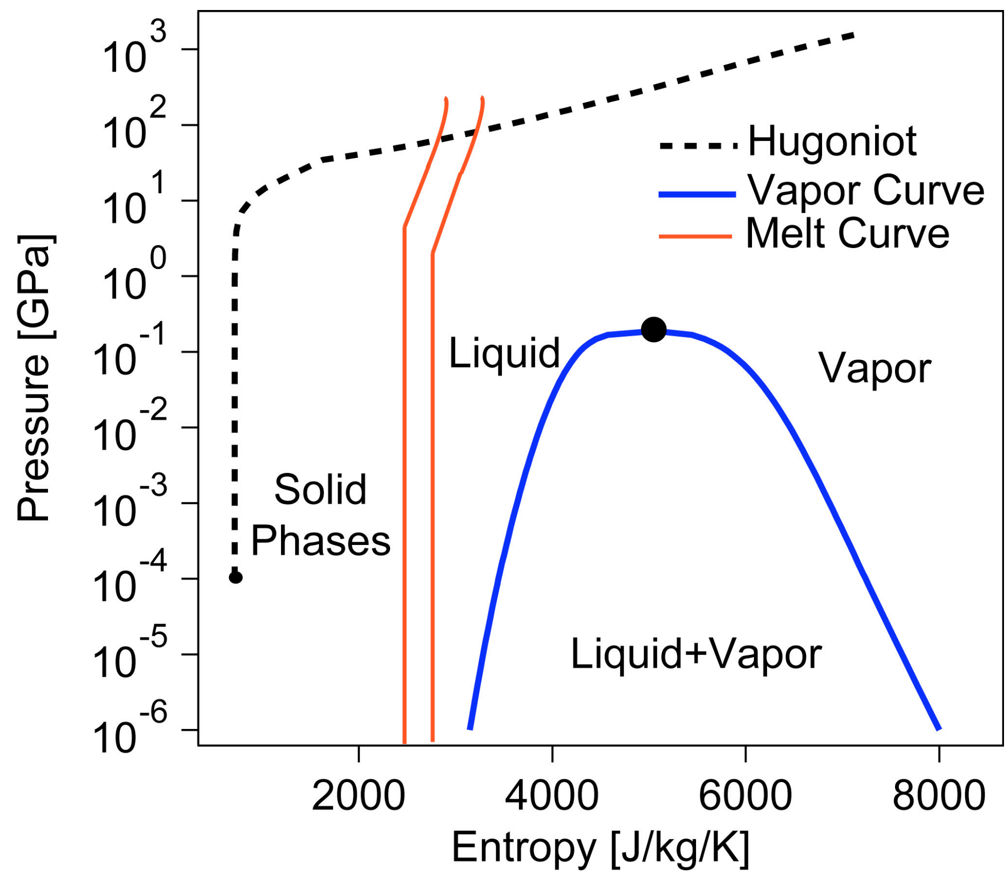
Entropy-temperature offers a more useful view of phase space for this purpose



Melosh (2007) model Hugoniot and vapor curve

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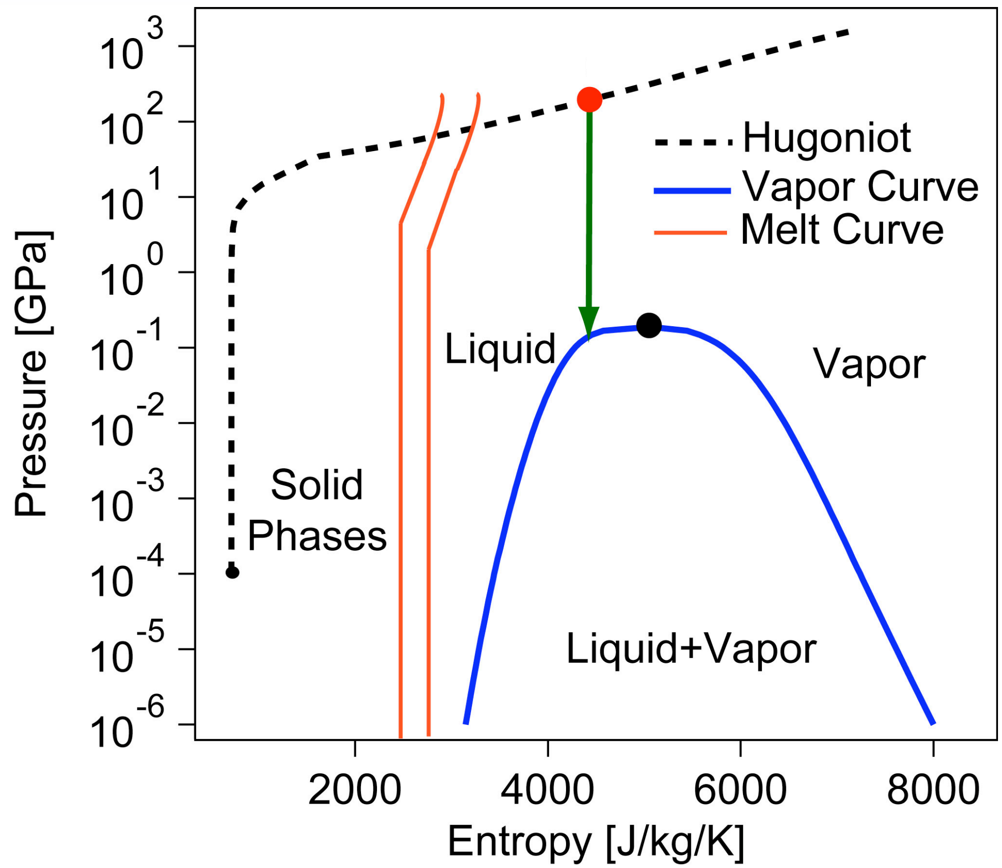
We will shock along the Hugoniot and release (isentropic) into, or above, the vapor dome

MgO experiments on Z

We have done initial MgO shock experiments on Z

We defined preparatory (ride-along) experiments and required diagnostics: **Temperature** (SOP)



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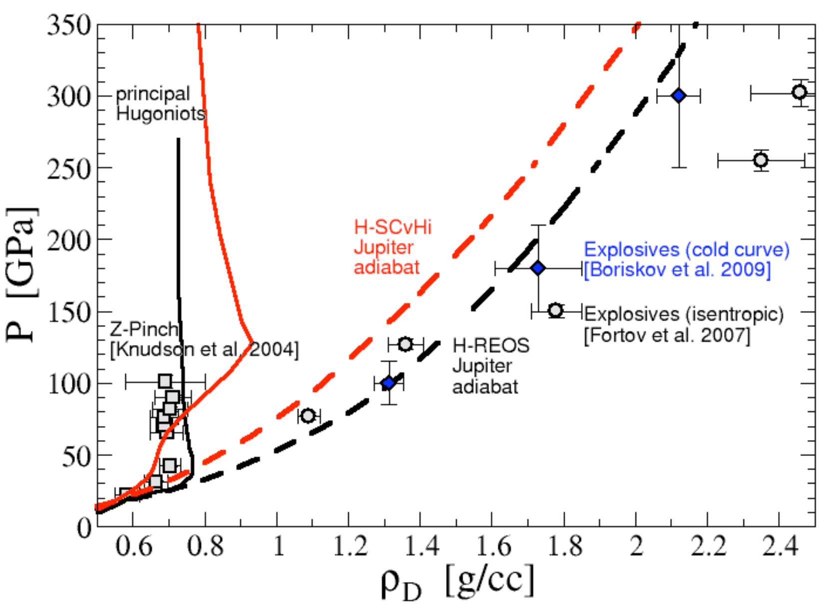
The accuracy of the equation of state of hydrogen is of key importance for modeling giant planets

- Hydrogen EOS targeting conditions at gas- and ice giants
  - High-precision experiments to distinguish between EOS for H, at 100 GPa along Jupiter isentrope
  - *Our aim is to decidedly shrink the error bars on Hugoniot and multiple-shock data to validate EOS models*



Jupiter adiabat using two different EOS (Nadine Nettelman)

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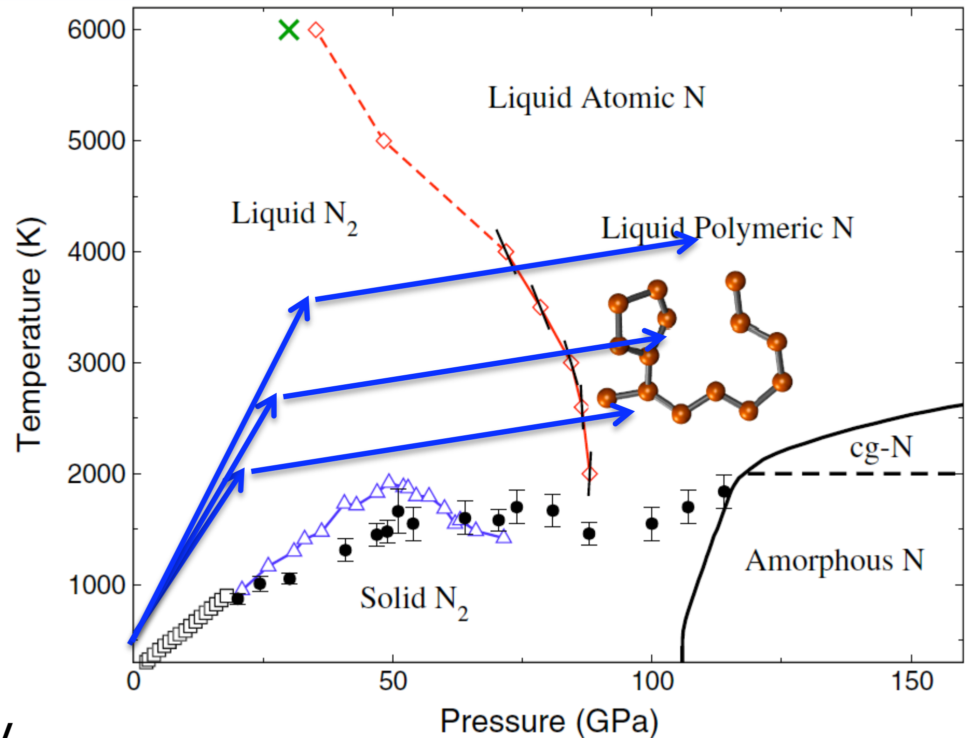
Investigating the fundamental behavior of molecular liquids under pressure

- Complex phase-diagram of nitrogen has similarities to that of hydrogen

- Confirm the existence of a liquid-liquid critical point
  - Shock-ramp technique to cross the phase boundary
  - 14% predicted volume change across the boundary



Phase diagram of nitrogen (Boates and Bonev 2009)

New ideas and extensions on existing plans in the two projects

- **Earth/ super earth**
  - Silicon isotope fractionation between phases: melt/solid
  - Viscosity of the vapor/liquid
  - Surface tension, timescales for homogenous nucleation
  - Pure Si, pure O_2, for O and Si core composition in iron alloys

- **Giant planets**
  - Core conditions
  - Rock/ice mix
  - Superionic water phase – detect!
  - Target multi-component aspect of the giant planets: H2O/CH4 mixture, clathrate initial state final state dense plasma

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Summary of discussions on the general topics

- **Grow team and the community**
  - Involvement of graduate students and postdocs*: obtain grants/ funding (NSF/DOE) and employ SNL sponsoring of students*
  - Participate at conferences and workshops to present work
  - The time-scale is a challenge: the fundamental science program can span 30-48 months before publication *a very long time from the perspective of a postdoc*

- **Diagnostics**
  - ***Temperature measurements by optical pyrometry***
  - Mie-scattering for detection of solid precipitates
  - X-ray Thomson scattering for temperature
  - X-ray diffraction for structure
  - Raman spectroscopy for chemical analysis

2011 workshop summary from a planetary perspective

- **Discussed CY12-13 project plans in detail**
  - Key diagnostics
  - Key supporting first-principles simulations
  - Timeline
  - Samples
- **Directions for future work**
  - Additional experiments
  - Grants
  - Simulations
- **Integration of project teams and solidifying common goals, directions, and expectations**