Carbon-Hydrogen Demixing and Hydrogen Metallization

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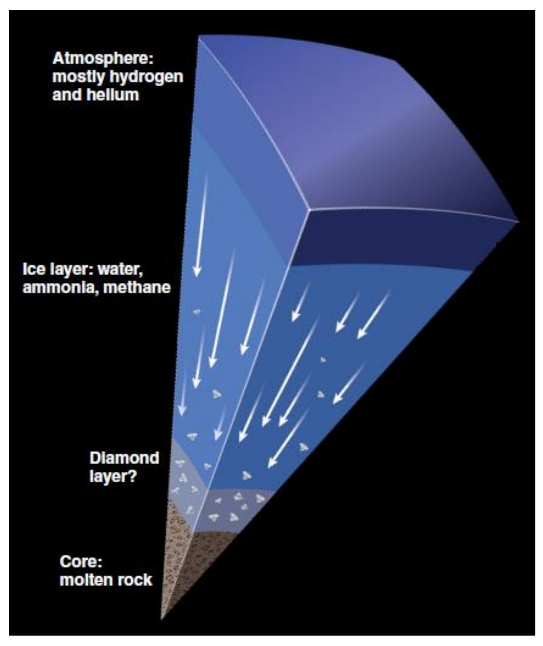
Summary

- At planetary interior conditions, diamonds are formed from polystyrene
- Simultaneously, a rise in reflectivity suggests that the hydrogen in the sample may be becoming metallic, which is energetically favourable at the conditions
- Repeating shots with these and other samples would help confirm this



Experimental Setup

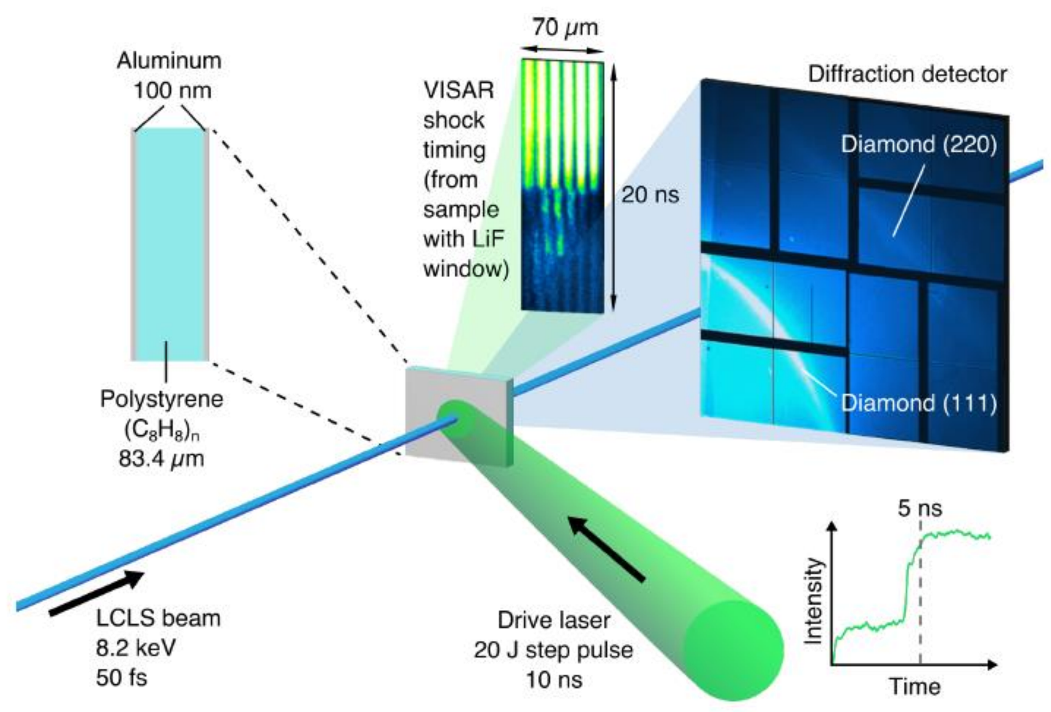


Figure 1: Experimental schematic, with optical laser drive beam, XFEL probe and VISAR

- Shaped laser pulse can drive multiple shocks
- We reach high pressure states with lower temperatures than on Hugoniot

Diamond Formation

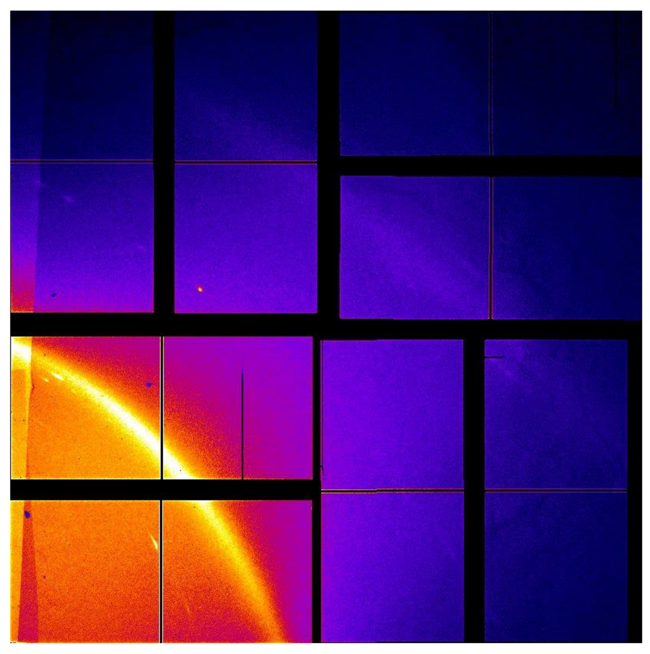


Fig. 2: Diffraction signal from shocked CH

- Diffraction data shows clear new peaks from polystyrene (CH)
- Conditions are 150 GPa, 5000 K
- Around 50% of carbon has crystallized within 10 ns

Metallic Hydrogen

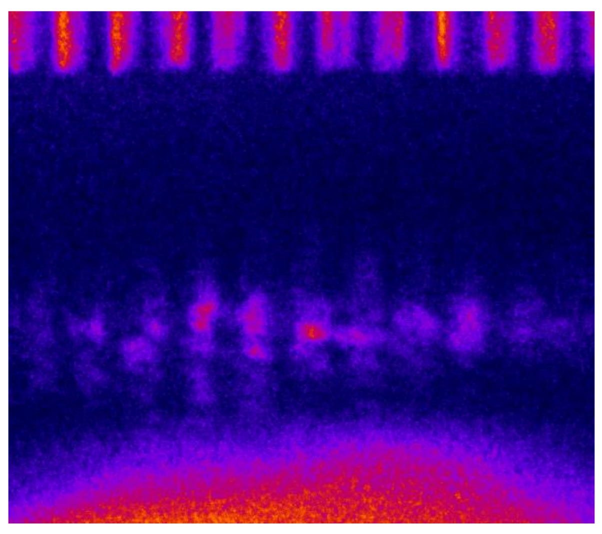
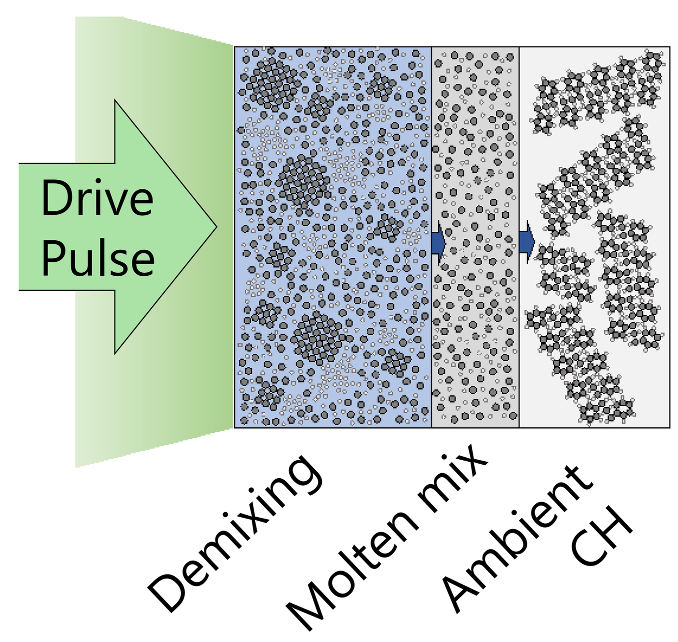


Fig. 5: VISAR signal, with reflectivity rise at 2nd shock

- VISAR probe shows rise in reflectivity with second shock
- Signature of metallization
- Diamond formation occurs in metallic H stability region

- Possible evolution:
  - 1st shock melts sample
  - After 2nd shock, hydrogen-rich regions metallize
  - Carbon-rich remnant crystallizes into diamond



Demixing

- A mixed system splits into regions with different atomic ratios
- Most studied example is H/He demixing
- Has implications for thermal transport, EOS etc.

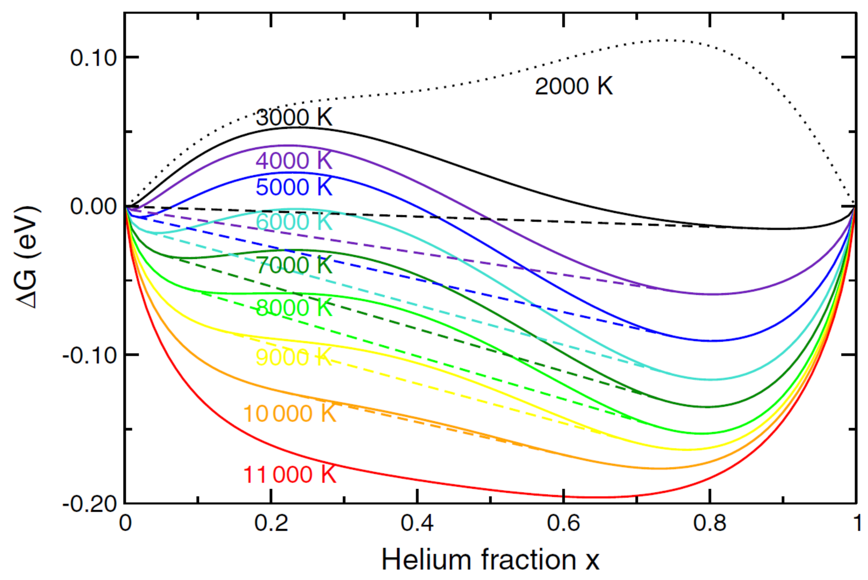


*Fig. 3: H/He enthalpy of mixing at 4 Mbar, from Lorenzen et al., **PRL** (2009)*

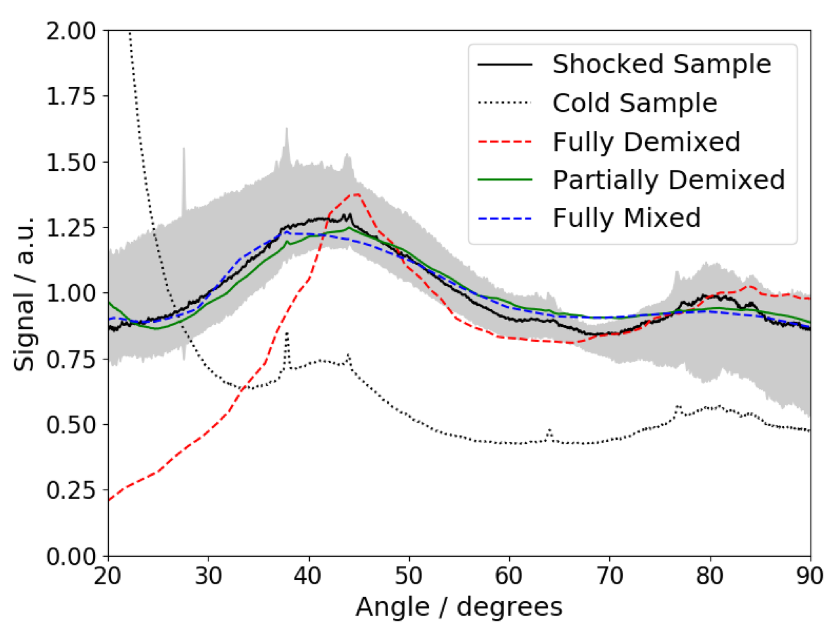


Fig. 4: CH scattering with (de)mixed fits from DFT-MD

- In CH mixture, demixing is expected to change diffraction
- We do not observe demixing in fluid CH at 50 GPa or 190 GPa (on Hugoniot)
- Enthalpy calculations suggest that we should

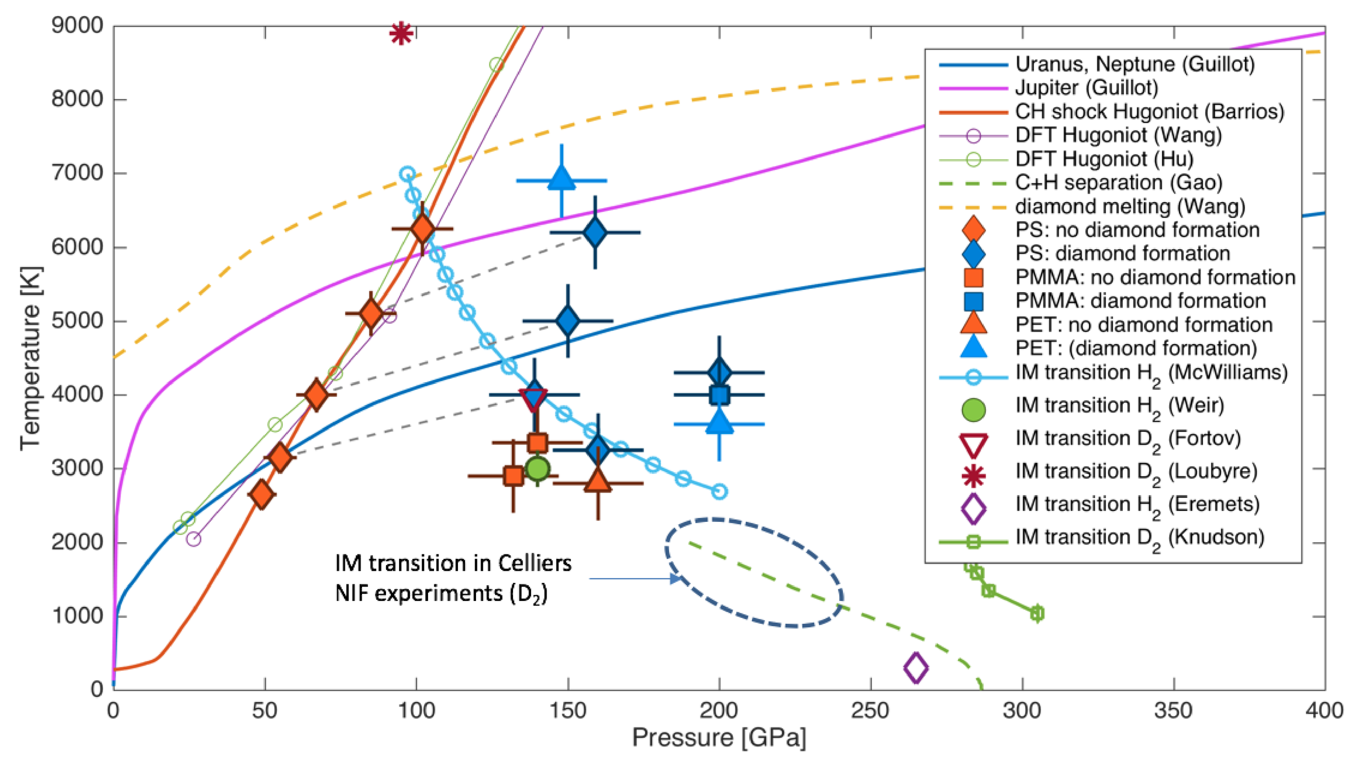


Fig. 6: CH phase diagram, with metallic hydrogen stability