**Sodium X-Ray Diffraction in the High-Pressure Regime**

X. Gong  
University of Rochester  
Laboratory for Laser Energetics

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**Graph**

- **Temperature vs. Pressure**
  - Melting curve
  - Isentrope
  - Liquid
  - Solid
  - bcc
  - fcc

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**Legend**

- Liquid
- Solid
- bcc
- fcc
- Isentrope
- Melting curve
- 59th Annual Meeting of the American Physical Society  
  Division of Plasma Physics  
  Milwaukee, WI  
  23–27 October 2017
A solid hP4 phase of sodium has been observed at ~320 GPa

- Na has been previously observed to transform into an optically transparent phase at 200 GPa*

- The phase is predicted by simulation to be a structurally complex “electride” hP4 structure*

- Na was ramp compressed to ~320 GPa on the OMEGA EP Laser System and studied using in-situ x-ray diffraction

- The existence of the hP4 phase at ~320 GPa indicates that the rise of the melting temperature starting at 120 GPa continues even at higher pressures

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Collaborators

University of Rochester
Laboratory for Laser Energetics

R. Smith, J. H. Eggert, and A. E. Lazicki
Lawrence Livermore National Laboratory

M. McMahon
Department of Physics, University of Edinburgh
At high pressures, Na has a unique melting curve* that possesses a minimum at 120 GPa, then rises steeply

Diamond-anvil-cell (DAC) experiments* show that Na transforms into an optically transparent phase at 200 GPa.

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This phase is predicted* to be an “electride” hP4 structure, where conduction electrons are “trapped” in interstitial wells, producing an insulator.

hP4: a double-hexagonal close-packed (dhcp) structure squeezed along the c axis.

Electron localization function

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The powder x-ray diffraction image-plate (PXRDIP)* diagnostic is used to obtain diffraction data of a compressed powder Na sample.

**VISAR: velocity interferometer system for any reflector
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Laser drive

Cu He$_\alpha$, 1.48 Å

X-ray source

C Na C

Tungsten pinhole collimator/reference

Delivered target drive and x-ray source drive the pulse shape

Power (TW)

$10^{-2}$

$10^{-1}$

$10^{0}$

Time (ns)

$0$ $5$ $10$ $15$ $20$ $25$

X-ray spectrometer drive 1-ns pulse

Target drive ramp pulse

The powder x-ray diffraction image-plate (PXRDIP)* diagnostic is used to obtain diffraction data of a compressed powder Na sample.

VISAR data are used to determine the velocity of the diamond free surface, which is back-propagated to determine the pressure in the Na sample.
Raw diffraction data are scanned from image plates on five sides of the box and projected onto a $\varphi$–$2\theta$ plane.
The four brightest lines are tungsten bcc* diffraction signals, which are used for calibration.

*bcc: body centered cubic
The three weaker lines are sodium diffraction lines, consistent with hP4 structure.
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Sodium has a solid phase at \(~320\) GPa, which is consistent with hP4 structure.
The melting temperature rises at >120 GPa
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- Na has been previously observed to transform into an optically transparent phase at 200 GPa*
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