Anomalous sound velocity in liquid heavy alkali metals at extreme conditions

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Alkali metals are very intriguing materials : they are considered as simple liquids at ambient conditions, but at high pressures their properties become more complex. Their phase diagrams exhibit some maxima in the melting curve at high pressure [1], [2], and some minima, meaning the material become liquid under strong compression. They can exhibit also a considerable variety of crystalline phases [3], transparency (at approximately 200 GPa in the case of Na [4]), and some liquid-liquid phase transitions (LLPT), for example a LLPT was reported in Rb at 12 GPa and 300°C [5].

Thermodynamic and elastics properties of liquid alkali metals are difficult to determine at extreme conditions with ultrasonic classical techniques, due to their high reactivity and the large sample size required. To overcome these difficulties, we combined diamond anvil cell with the picoseconds acoustics technique [6], which is an optical pump-probe technique similar to pulse-echo ultrasonic technique, non-destructive and contactless.

Little is known about the phase diagram of Rb above 8 GPa (see Fig.1). On the contrary, the phase diagram of Cs is best known, including two maxima in the melting line and a deep minimum at 4.8 GPa and 370°C [2]. We report the phase diagrams and the sound velocities in liquid heavy alkali metals Cs and Rb measured by picoseconds acoustics. In these two liquid metals, the evolution of the sound velocity is complicated. The sound velocity in liquid Cs shows similarities with the underlying solid phase. No LLPT was found in the P-T range considered here (0-15 GPa, 300°C) for liquid Rb. These measurements open the way to determine the equation of state and the thermodynamic properties of liquid Rb and Cs [7].

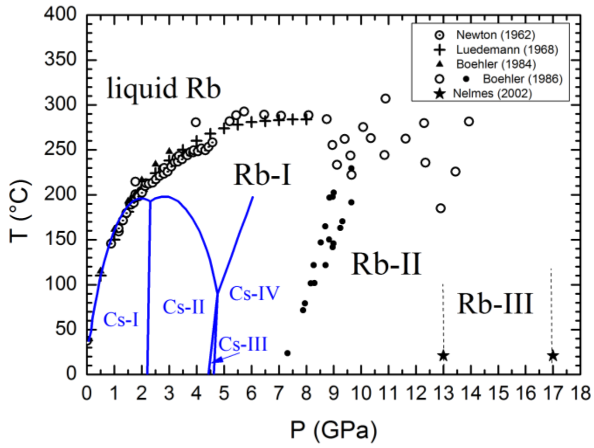

Figure 1. This P-T diagram shows the current knowledge on the phase diagram of Rb (data points) and the comparison with the phase diagram of Cs (blue lines).

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