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Ultrasonic P-wave velocity measurements of Fe-S-Ni liquid metal at 10 GPa

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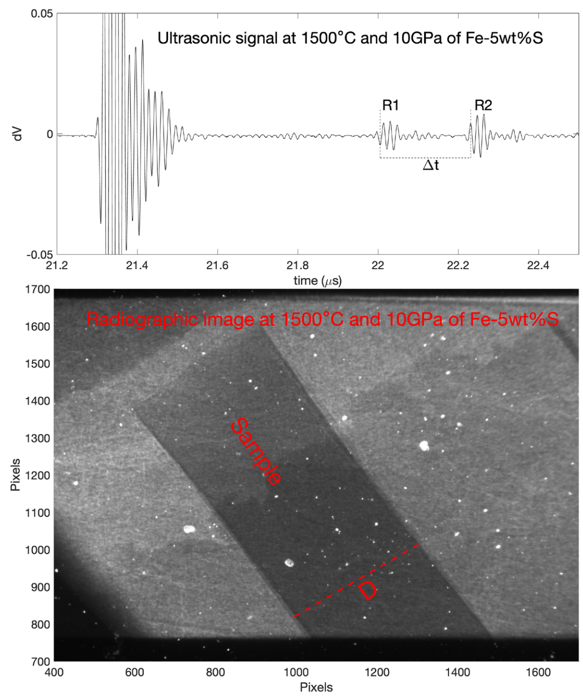

The iron-rich cores of Mercury (~5-35 GPa) and Mars (~20-40 GPa) are at least partially liquid. The low oxygen fugacity inferred for Mercury and high oxygen fugacity inferred for Mars suggest that the light element budget of Mercury's core is possibly dominated by silicon whereas the light element budget of the Martian core is possibly dominated by sulfur. Validating such geochemical inferences by geophysical methods requires profound knowledge of material properties of the candidate liquid core alloys which can be constrained geophysical measurables of the planet. Mercury's core density is constrained by the measured physical librations of the surface and the obliquity of the planet. The density structure Marsis constrained by tides and by recent seismic data obtained by NASA's Insight mission.

We present new measurements of the P-wave velocity at 10 GPa of iron-rich metallic liquid samples with 5 wt%S, 10 wt%S and 20 wt%S, with and without additional 10 wt%Ni. These measurements are performed using the Speed-1500 multi-anvil apparatus at beamline BL04B1 of the Spring-8 synchrotron facility in Sayo, Japan [1]. The P-wave velocity is measured as $VP = \frac{2D}{\Delta t}$, with Δt the two-way travel time of sound waves through the sample, and D the sample width (see figure).

The measurements will be discussed in relation to reported measurements in literature and used to constrain the equations of state of these liquid metal alloys at pressures relevant for the liquid cores of Mercury and Mars. P-wave velocity measurements on Fe-5wt%S at high pressure were nonexistent in literature and are specifically of interest for the core of Mercury which relative high density excludes a large abundance of light core elements. P-wave velocity measurements at high pressure of liquid iron alloys with 10wt% and 20wt%S are available in literature. But measurements on binary Fe-S compositions and those with added Ni are not in agreement [2,3]. Our measurements with and without Ni will clarify whether the added Ni is the cause of the differences reported.

[1] Greaux et al., (2019), Nature, 565, 218-221.
[2] Nishida et al. (2020), Nat. Comm. 11, 1954.
[3] Terasaki et al. (2019), JGR Planets, 124(8), 2272-2293.