Density of Fe-Ni-C liquids at high pressures and implications to liquid cores of Earth and Moon

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The presence of light elements in the liquid cores of Earth, Moon and other terrestrial bodies has been widely proposed; however, the specie(s) and concentration(s) of light element(s) in the cores are still poorly constrained. Carbon is among the top candidate light elements in planetary cores, in light of its high cosmical abundance, siderophile nature and ubiquity in iron meteorite. There exist controversies in recent studies on whether carbon can be the major element in Earth's or Moon's liquid outer core, mainly due to the challenge on measuring liquid density at high pressures [*Lai et al.*, 2017; *Sanloup et al.*, 2011; *Shimoyama et al.*, 2013; *Steenstra et al.*, 2017; *Terasaki et al.*, 2010]. Here we will present the measurements of the densities of liquid $Fe_{90}Ni_{10}$-3 wt.% C up to 9.6 GPa and 1900 ºC using the synchrotron-based X-ray absorption method. The experimental results show that the density of $Fe_{90}Ni_{10}$ - 3 wt.% C increases from 6.86 to 7.44 g/cm^3 from 0 to 9 GPa and at 1700 ºC and expands about 1.4% from 1700 ºC to 1900 ºC at fixed pressures. The density of $Fe_{90}Ni_{10}$ was lowered by ~2-3% with a 3 wt.% C incorporation. More intriguingly, the Fe-Ni-C alloy was found to own a higher bulk modulus (K_0) than Fe-Ni alloy while lowering its density. It is consistent with a theoretical calculation [*Belashchenko et al.*, 2011] and with the relation in solid iron and iron carbide, but different from some previous results which suggested Fe-C liquid is more compressible [*Shimoyama et al.*, 2013; *Terasaki et al.*, 2010]. The compressional velocity (v_p) of Fe-Ni-C alloy may thus be higher than the previous estimate. Besides, the

bulk moduli of Fe-C and Fe liquid at Earth's core pressure mainly relies on its pressure derivative (K') instead of K_0, and this parameter remains highly uncertain due to the limited experimental pressure range at <10 GPa. These two reasons make carbon remain a candidate of the light element in Earth's outer core. Moreover, the high v_p of Fe-Ni-C alloy fits the reference v_p of liquid lunar core of 4.1 km/s [*Weber et al.*, 2011] at ~7 GPa, raising the likelihood that carbon be the dominant light element in lunar outer core and providing an estimate of the size of lunar core accordingly.

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