Melting experiments on Fe₃S under high pressure

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The Earth’s core is mostly composed of iron and nickel alloy but with some portion of light elements. Though there have been many attempts to define the light element in the core, there is no solid consensus as to the composition of the core. To date, there have been a number of candidate elements identified, such as silicon, oxygen, and sulphur.

Sulphur is particularly important element to consider due to its siderophilic nature. Many iron meteorites, which are believed to be the cores of destroyed planetesimals, show very high sulphur contents. The system Fe-S has therefore been of great interest as a model core system. The iron-rich compounds are important for Earth’s core as the dense solid inner core is crystallised from the less dense liquid outer core. Fe₃S is the most iron-rich sulphide phase and stabilised at high pressure. The thermodynamic properties of Fe₃S were less studied compared to other iron compounds mostly because the single phase of Fe₃S is difficult to synthesise from powder mixtures under high pressures. As a result, existing melting data only concerns the melting of the binary eutectic system, and not the end member Fe₃S, which limits the ability to extrapolate data to conditions of the Earth’s core and thermodynamic modelling capabilities.

We have investigated the melting behavior of Fe₃S using in situ high pressure/temperature X-ray diffraction experiments in laser heated diamond anvil cells up to 100 GPa. Pressure transmitting medium of Al₂O₃, SiO₂, or KBr was used in the experiments. We used a flake-shaped amorphous alloy with a composition of Fe₃S. Melting was determined using disappearance of diffraction peaks associated with Fe₃S, and through textural analysis of recovered samples. Synchrotron X-ray in-situ experiments were performed at beamline BL10XU (SPRING-8) and P02.2 (PETRA III).

We will report new experimental data and discuss the melting temperature of Fe₃S under Earth’s core pressures. We will also discuss the implications of our data to the effects of sulphur on Earth’s core properties.

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