Mineral-physics constraints on planetary cores: the Fe-FeS and the Fe-FeSi systems

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The physical properties of iron and iron alloys at high pressure and high temperature are crucial for understanding the structure, chemical composition, evolution, and dynamics of planetary interiors. Indeed, the inner structures of all the telluric planets have a similar layered nature: a central metallic core composed mostly of iron, surrounded by a silicate mantle, and a thin, chemically differentiated crust. However, differences in bulk masses and radii suggest different compositions and different mantle to core size ratios, and imply different pressure and temperature conditions in the center of various planetary bodies. This also reflects on the solid versus liquid state of the core and on the stable crystalline structure of its solid phase. Such a structural and compositional variability greatly influences the planet’s heat budget and internal dynamics, including the occurrence of internal convection, and magnetic field generation in the core.

Among the physical properties that are required to understand planetary cores, density and sound velocities are of primary importance, as these can be directly related to seismological observations (Earth’s seismological models, Apollo records for the Moon or incoming results from the InSight mission on Mars). Here I will discuss density and sound velocities at high pressure and high temperature of solid fcc-Fe and liquid Fe-S alloys. These results will be used to model the Moon’s core. Concerning the Earth, I will focus on sound velocity-density systematics at high pressure of solid hcp-Fe and hcp-Fe-Si alloys to place constraints on the Si content of the Earth’s inner core.

Keywords: density and sound velocities, high pressure and high temperature, solid fcc- and hcp-Fe, solid Fe-Si alloys, liquid Fe-S alloys

