Experiment Report - HS- 3677

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"Origin of the f-electron localization-delocalization phenomenon in cerium"

During our x-ray diffraction in Diamond anvil cell experiment at ID09, we show that a crystal of pure cerium does not behave as expected for a solid. At ambient temperature and subjected to very high pressures of 0.75 GPA using a diamond anvil cell apparatus, the initial phase (called gamma) of a Ce single-crystalline sample transforms to a new one (called alpha) with about 15% of volume collapse. Surprisingly, the single-crystal quality remains, and even more astonishing: one can observed in the same sample the coexistence of two single-crystals with two different volumes, but the same crystal structure. In order to explain such extraordinary observation, we support the existence of an isostructural first-order diffusionless phase transformation with a large volume jump, an unparalleled picture of phase transition in solid-state matter.

We further applied the x-ray diffraction method to determine the high pressure variation of the cerium volume along different isotherms. Our data clearly show that the transformation mechanism can be here described on the basis of crystallographic and thermodynamic arguments, showing a fair agreement with an isomorphic scenario and the existence of a critical point. For the first time, the equation of state of cerium at the critical temperature is determined experimentally and is shown to be well understood in the framework of the scaling theory of the liquid-gas transition of classical systems.

This conclusion represents an important step forward in achieving a reliable and unambiguous picture on the mechanism of phase transformation in cerium, archetypical of localization-delocalization phenomenon encountered in f-electron systems.

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