GHz CONDUCTIVITY MEASUREMENTS OF THE *f*-ELECTRON ELEMENT CERIUM

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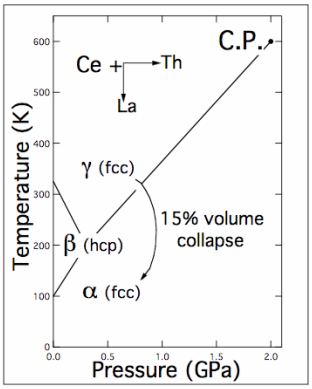
Elemental Cerium undergoes a series of structural phase transitions on cooling from 500 K down to cryogenic temperatures (see Figure (a) below). These are believed to be associated with the localized or delocalized nature of the *f*-electrons. None of the transformations are complete and all have a large degree of thermal hysteresis, complicating any measurement of pure Cerium as it is never entirely clear what fraction of each phase is present at a given time. For this reason Cerium is often doped with Thorium, which suppresses the β-phase, and Lanthanum, which shifts the γ - α transition to lower temperatures (see Figure (a)). Nevertheless, despite the difficulties, we decided to embark upon an investigation of the effect of high-magnetic fields on elemental Cerium using a GHz-conductivity technique. All the measurements were performed with the sample acting as a small perturbation to a resonant cavity placed in a superconducting magnet at the NHMFL in Los Alamos.

(a)



(b)

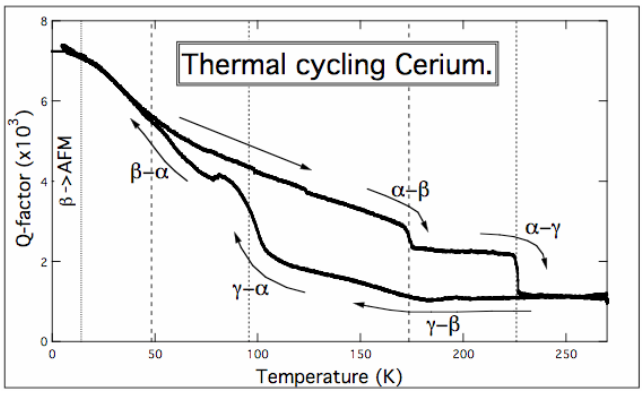


Figure (b) above shows the typical effect of thermal cycling on the Q-factor of the cavity. The features can be attributed to the various phase transitions by the temperature at which they occur. Note the large hysteresis between the features in the cooling and warming curves. Unless the sample is quench-cooled, which was not the case, it is certain that both α and β-phases are present at low temperatures.

(c)

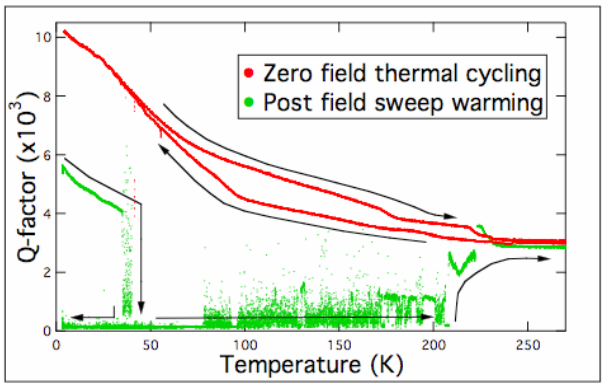


Figure (c) left shows how the temperature dependence of the Q-factor changes subsequent to a magnetic field-sweep to 12 T at low temperatures. The top curve is a "virgin" thermal cycle similar to that in Figure (b). After the field-sweep at 3.5 K the Q-factor halves and then drops to nearly zero as the temperature is raised above 40 K. This implies that the sample has been altered in such a way so that it is no longer a small perturbation to the cavity. The effect is also observed in the field dependence of the resonant frequency (not shown). The first field-sweep following cool-down shows an enormous (15%) jump in the frequency, and subsequently smaller features are observed at fixed magnetic fields in all the resonant modes of the cavity.

The zero Q-factor is retained at all temperatures until the sample is warmed above 200 K, after which the initial, pre-field-sweep behavior is recovered. We tentatively suggest that performing field-sweeps at low temperatures has the effect of stabilizing the β-phase in preference to the α-phase. The β-phase has a large magnetic susceptibility and so is more likely than any of the other phases to "couple" with the magnetic field. Also a large change in the relative permeability of the sample associated with the formation of the β-phase could lead to the quenching of the Q-factor. Warming the sample above 200 K would cause a large portion of the β-phase to transform into the γ-phase, resetting the sample back to something akin to its initial state.