Observation of Zero Resistance at 153 K in Cuprate Superconductors

In 1911, Kamerlingh Onnes found that the resistivity of mercury at below T_c=4.2 K vanished. Since this discovery, superconductivity has been one of the most intriguing and extraordinary properties of condensed matter for more than 100 years. In addition to vanishing resistivity, superconductors exhibit various unique properties such as the Meissner effect, the Josephson effect, etc. As a result, superconductivity has been a subject for a variety of application-oriented research as well as for fundamental physics. To raise critical temperature T_c, above room temperature, in particular, has been the dream of many researchers. High T_c cuprates found in 1986 raised the critical temperature from liquid helium to above the temperature of liquid nitrogen within several years. However, the highest T_c at ambient pressure is at present ~135K of $HgBa_2Ca_2Cu_3O_{8+\delta}$ (Hg-1223), and has been so for about twenty years since 1993.

The critical temperature often increases under high pressure. There was a report that the critical temperature became as high as T_c=164 K under pressure of 31 GPa for Hg-1223. This has often been claimed as the highest superconductivity which has so far been observed. In this experiment, however, the observed resistivity never dropped down to zero, but exhibited only a slight decrease with lowering temperature. The critical temperature was determined by an onset of this decrease rather than the required zero resistance.

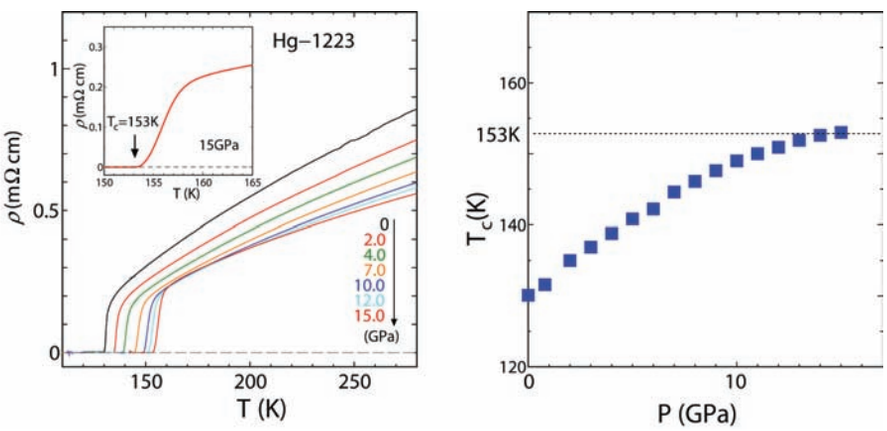

Fig. 1: (a) Observed resistivity of Hg-1223 under pressure. The inset is the enlargement in the vicinity of the critical temperature under 15 GPa. (b) The critical temperature as a function of the pressure.

Quite recently, Takeshita and coworkers [1] prepared high quality samples of Hg-1223 and applied hydrostatic pressure up to 15 GPa, and actually observed zero resistance at 153 K as shown in Fig. 1 (a). Further, the curve of the observed T_c versus pressure shown in Fig. 1 (b) indicates that the critical temperature is likely to increase further under higher pressure. It is regarded as the highest superconducting zero resistance state in history. Such accurate and quantitative measurement of the pressure dependence of superconducting properties, which became possible only recently, is expected to play an important role in our understanding of the mechanism of high T_c superconductivity.

References

[1] N. Takeshita, A. Yamamoto, A. Iyo, and H. Eisaki, J. Phys. Soc. Jpn. 82 (2013) 023711