# Effect of pressure on the superconducting transition in the Dirac semimetal $PdTe_2$

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The transition metal dichalcogenide $PdTe_2$ attracts much attention because of its classification as a type-II Dirac semimetal with a topologically non-trivial surface state. Moreover, it is a superconductor at low temperatures. A recent study of superconductivity at ambient pressure revealed that $PdTe_2$ is a bulk type-I superconductor with $T_c$ = 1.64 K [1]. The critical field $H_c(T)$ follows the standard quadratic temperature variation with $\mu_0 H_c(0)$ = 13.6 mT. Intriguingly, surface superconductivity is identified with $T_c$ = 1.33 K, which is lower than $T_c$ of the bulk. It persists up to $\mu_0 H_c^S(0)$ = 34.9 mT, but does not follow the standard Saint-James – de Gennes behavior. With regards to the effect of pressure on $PdTe_2$, a theoretical study by Xiao *et al*. reported the depression of superconductivity up to 10 GPa, as well as a transition from the type-II Dirac semimetal to type-I in the pressure range 4.7 - 6.1 GPa [2]. In this experimental study, we report the effect of high pressure up to ~2.5 GPa on superconductivity in $PdTe_2$ [3].

Electrical resistivity, $\rho(T, H)$, and ac-susceptibility, $\chi_{ac}(T, H)$, under high pressure were measured utilizing a clamp-type piston-cylinder cell. Two single crystals for $\rho$ and $\chi_{ac}$ were loaded into a Teflon capsule together with an ac-coil set and a pressure-transmitting medium (Daphne7373) for hydrostatic compression. The generated pressure in the capsule was estimated from the calibration data for this cell, which was obtained in a separate experiment. Data were taken in applied dc-magnetic fields, $\mu_0 H_a$, up to 180 mT for $\rho$ and 30 mT for $\chi_{ac}$. The experiments were performed in two runs on the same sample pieces up to pressures of 1.24 and 2.49 GPa, respectively.

The superconducting transition temperature as a function of pressure is shown in Figure 1. $T_c^R$ is obtained from $\rho(T)$ and $T_c^\chi$ and $T_c^S$ from $\chi_{ac}(T)$, respectively. $T_c^R$ and $T_c^\chi$ originate from bulk superconductivity and show a good agreement between them, especially up to 1.24 GPa. The transition temperature reaches a maximum value of 1.91 K around 0.91 GPa and then decreases to 1.27 K at 2.49 GPa as pressure increases. Similar to $H_c(T)$ at ambient pressure, $H_c(T)$ under pressure defined by $T_c^\chi$ follows the quadratic temperature variation for type-I superconductivity as well. Furthermore, the $H_c(T)$-curves at all pressures collapse on a single universal curve. This strongly supports that type-I superconductivity is robust under pressure. Interestingly, in $\chi_{ac}(T)$ at pressures of 1.41 to 2.49 GPa, a second transition appears at $T_c^S$ above $T_c^\chi$. The inset of Figure 1 shows the 2.49 GPa curve as an example. The second transition is attributed to the surface superconductivity mentioned above. $T_c^S$ below 1.41 GPa is obtained from the field-temperature phase diagrams by extrapolating $T_c^S(H)$ to zero field [3]. The pressure variation of $T_c^S$ with a maximum near 0.9 GPa is comparable to the one for the bulk $T_c$. $T_c^S$ survives at the highest pressure we measured and is higher than $T_c^\chi$ above 1.41 GPa, indicating that the surface superconductivity is also robust under pressure. Unlike the $H_c(T)$-curves, the reduced plot of the $H_c^S(T)$-curves to $T_c^S$ shows pressure variation. The behavior of $T_c^S$ and the $H_c^S(T)$-curves under pressure implies that the surface superconductivity of $PdTe_2$ may possibly have a non-trivial nature. In addition to the pressure variation of $T_c$, we will report in this contribution the field-temperature phase diagrams of $PdTe_2$ under high pressure.

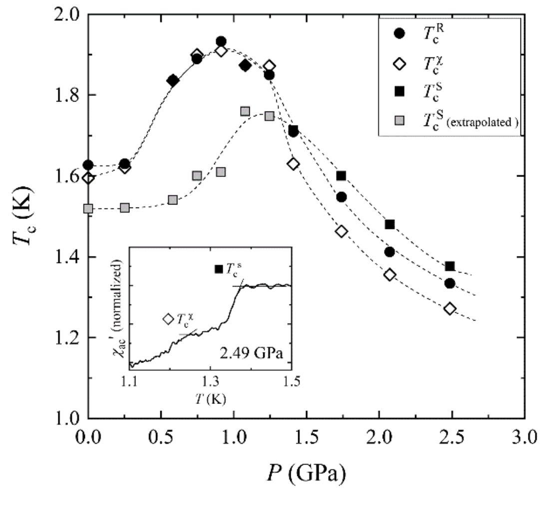


*Figure 1.* Pressure variations of the superconducting transition temperature at $\mu_0 H_a = 0$. $T_c^R$ (closed circles) is determined from resistance, and $T_c^\chi$ (open diamonds) from ac-susceptibility. $T_c^S$ denotes surface superconductivity (closed and grayish squares). Grayish squares are the extrapolated values of $T_c^S$ at $\mu_0 H_a$= 0. The dashed lines are guides for the eye. The inset shows how $T_c^\chi$ and $T_c^S$ are extracted from the ac-susceptibility at $P_{max}$= 2.49 GPa.

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