Supplementary Materials: Interaction of in-plane Drude carrier with c-axis phonon in $PdCoO_2$

(Dated: June 13, 2023)

CONTENTS

I. EXTENDED DRUDE ANALYSIS OF Pd-FILM

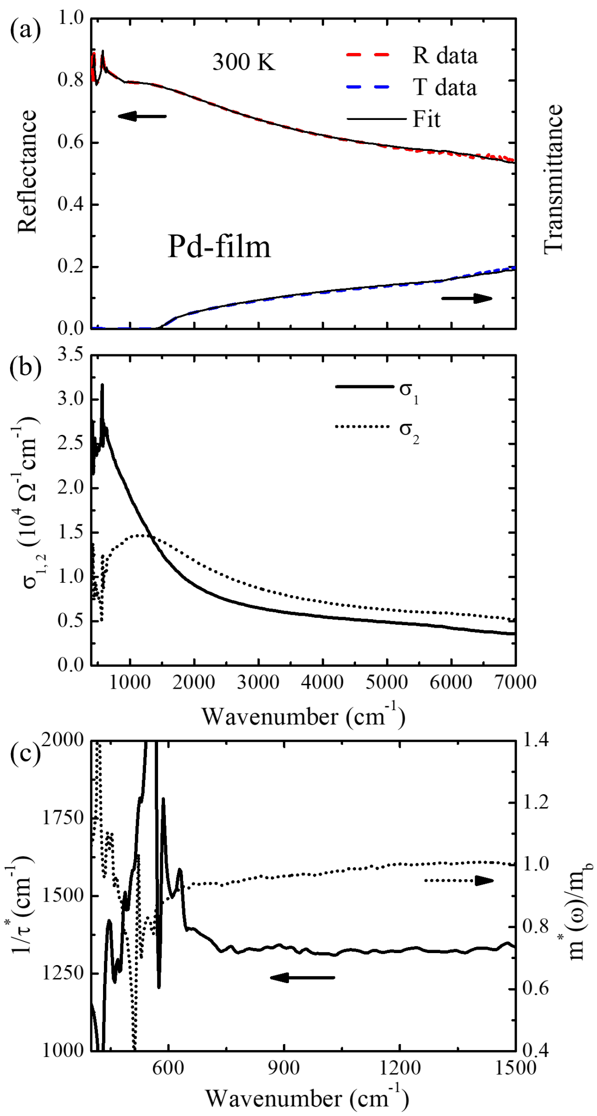

Fig. S1. (a) Reflectance and transmittance of a $d = 15$ nm Pd thin film. (b) Optical conductivity (real and imaginary) obtained by fitting the R and T. (c) The frequency-dependent scattering rate $1/\tau^*(\omega)$ and mass enhancement $m^*(\omega)/m_b$ calculated from $\sigma_1(\omega)$ and $\sigma_2(\omega)$

II. CHARACTERIZATION OF Al_2O_3 SUBSTRATE PHONONS AND THEIR EFFECTS ON $PdCoO_2$-FILM AND Pd-FILM

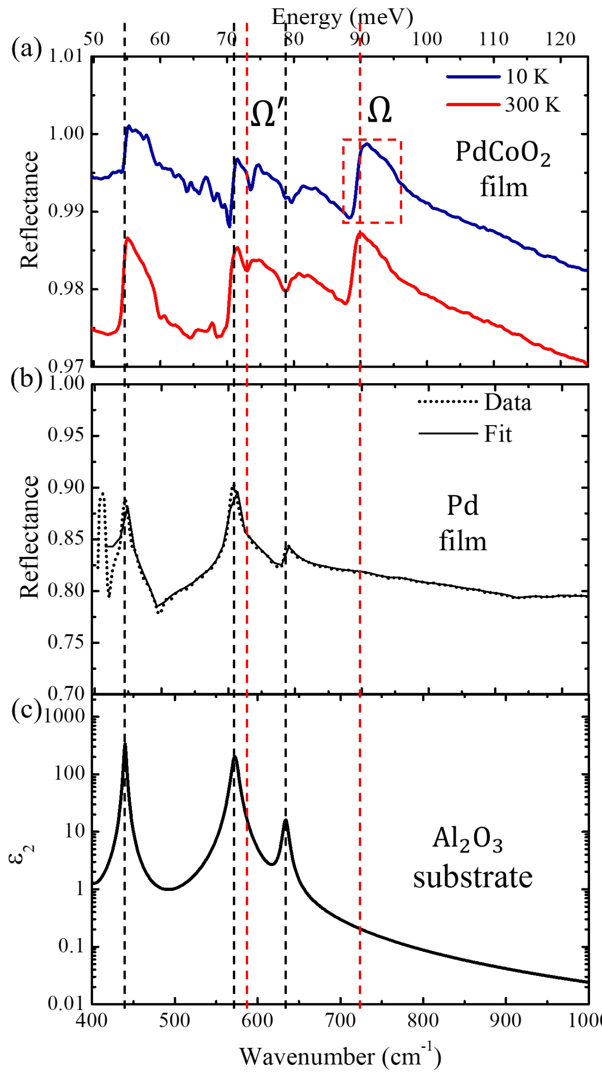

Fig. S2. Reflectance of (a) $PdCoO_2$ thin film and (b) Pd thin film compared with (c) the dielectric function $\varepsilon_2(\omega)$ of the bare Al_2O_3 substrate. The dashed lines (black) indicate the three optical phonons of Al_2O_3. Importantly, the red-dashed lines show that Peak-Ω (and dip-Ω') are absent in the Al_2O_3 and Pd-film.

III. CALCULATION OF THE S- AND P-POLARIZED REFLECTANCE FOR GRAZING INCIDENCE

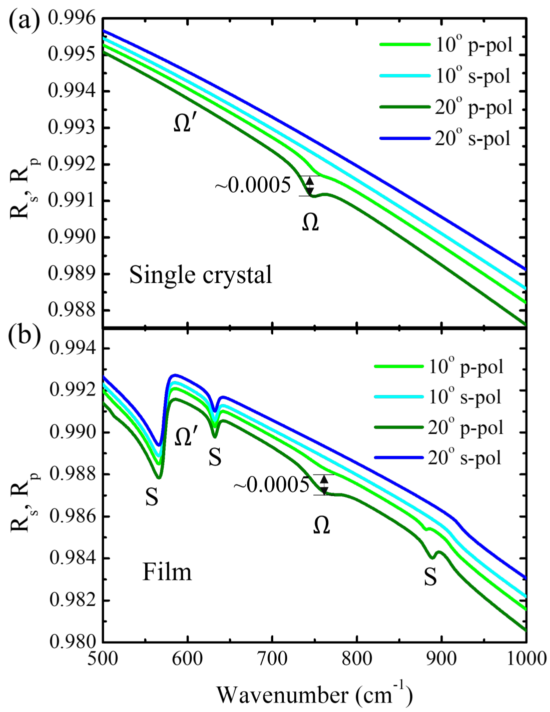

Fig. S3. Grazing-incidence reflectance calculated at the incidence angles $\theta_{in} = 10°$ and $20°$ for (a) single crystal and (b) thin film, respectively. In the calculation, we used the c-axis complex dielectric function $\varepsilon_c(\omega)$ of $PdCoO_2$ obtained from Fig. 3, and a simple Drude $\sigma(\omega)$ for the ab-plane. Ω and Ω' show the optical features that arise from the c-axis dielectric function through the E-leakage. In (b), 'S' stands for the substrate Al_2O_3.

IV. COMPARISON OF Ω .VS. Ω_c AND Ω'.VS. Ω'_c

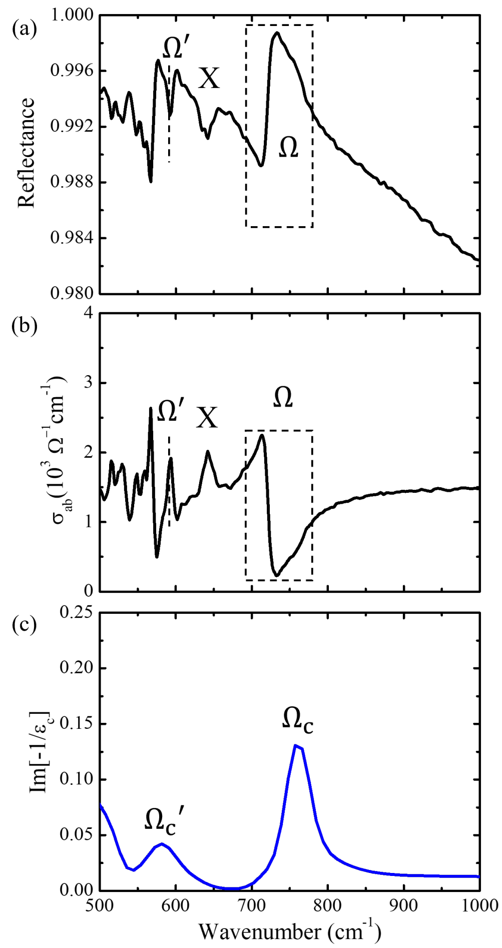

Fig. S4. (a) Reflectance of the $PdCoO_2$ thin film (b) ab-plane optical conductivity (c) c-axis dielectric loss function. Ω shows similar position and width as Ω_C. However, as for Ω', $\sigma_1(\omega)$ is highly uncertain in the region of Ω', hindering precise determination of the spectral shape , making the comparison with Ω'_C difficult. A TO phonon of $PdCoO_2$ and a substrate phonon accidentally coincide at the position Peak-X.

V. m^* AND $1/\tau^*$ IN THE HIGH FREQUENCY RANGE

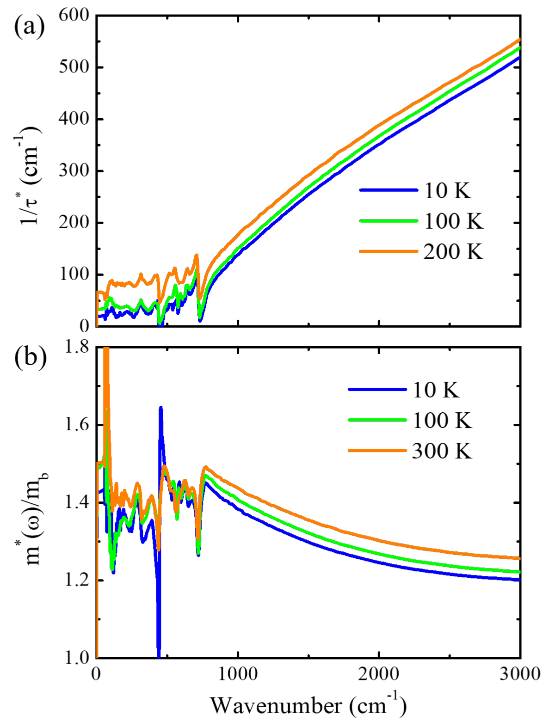

Fig. S5. $1/\tau^*(\omega)$ and $m^*(\omega)/m_b$ continue to change as ω increases above Ω. In standard electron-phonon interaction, they become flattened at ω well above Ω. The continued changes of $1/\tau^*(\omega)$ and $m^*(\omega)/m_b$ indicate that additional scattering sources like electron-electron scattering may exist in addition to the electron-phonon coupling.