Interfacial Electron-Phonon Coupling Constants Extracted from Intrinsic Replica Bands in Monolayer FeSe/$SrTiO_3$ - SUPPLEMENTAL MATERIAL

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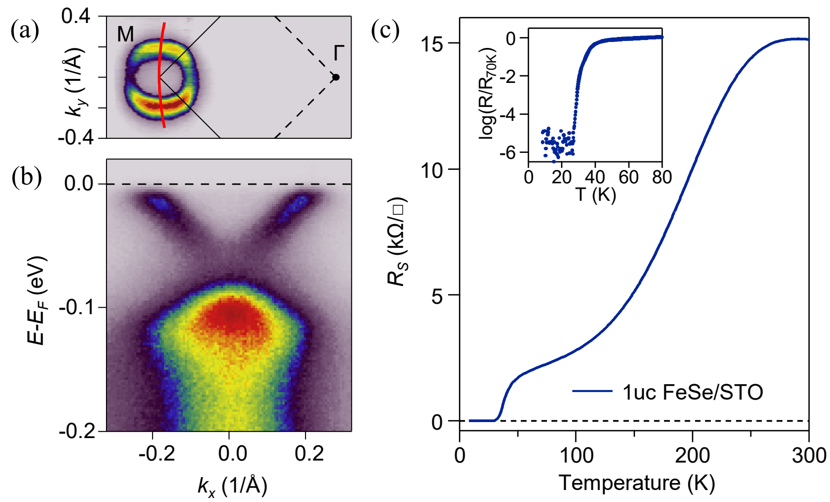

Figure S1. **Combined *in situ* ARPES and electrical resistivity measurement of monolayer FeSe/SrTiO$_3$ prior to transportation to ALS.** (**a**) Fermi surface intensity map for an as-grown monolayer FeSe/SrTiO$_3$ sample held at 12 K, integrated over $\pm$5 meV of E_F. The black solid line indicates the boundary of the 2-Fe Brillouin zone. (**b**) Photoemission intensity at M (red line in Panel A) taken at 12 K. ARPES measurements shown in (a) and (b) were performed using a He plasma lamp with unpolarized light, $h\nu$ = 21.2 eV. (**c**) Temperature-dependent sheet resistance for the identical film measured *in situ* in a vacuum better than 1×10^{-10} Torr. The inset shows the low temperature data in log scale.

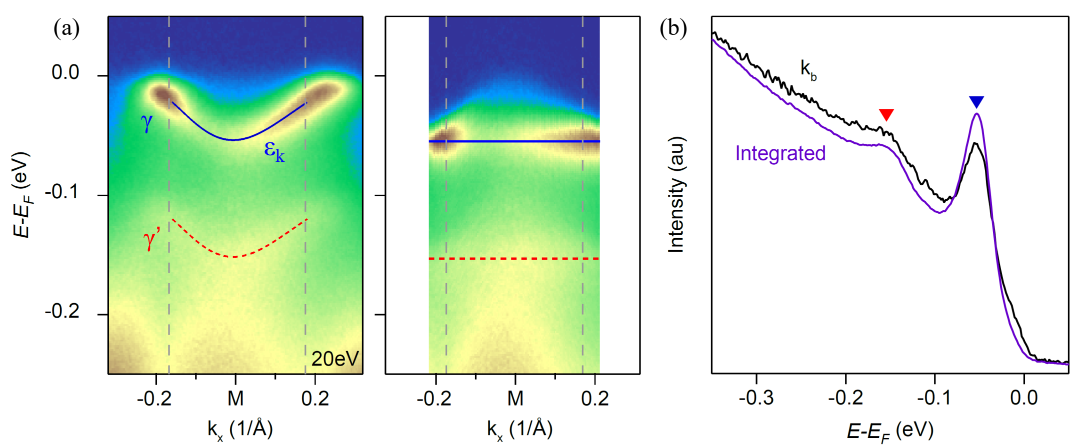

Figure S2. **Processing procedure used to generate integrated EDC's around the electron pocket at M.** (**a**) Example 20 eV ARPES spectra at M before (left) and after (right). Blue and red dashed lines highlight the EDC peak positions for the main and replica bands, respectively. (**b**) EDC's are then integrated over the inner 80% of k_F (within the dashed grey lines in (a)) to produce the purple curve, shown in comparison to a raw EDC collected at M (black). Data presented in Fig. 2(a) of the main text are integrated over both k_x and k_y within the equivalent region around M.

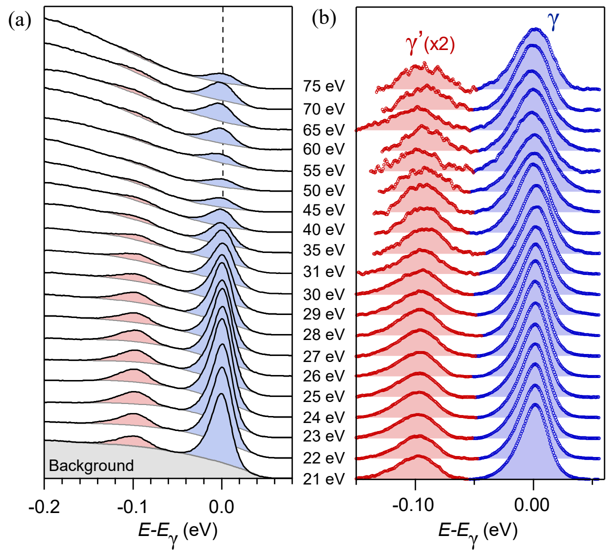

Figure S3. **Photon energy dependent EDC's after background subtraction.** (**a**) Integrated EDC's collected from $h\nu$ = 21 to 75 eV, as shown in Fig. 2(a). (**b**) The same data as in (a), after subtracting the spline background from each EDC. The γ' feature is multiplied by 2 for visual clarity.

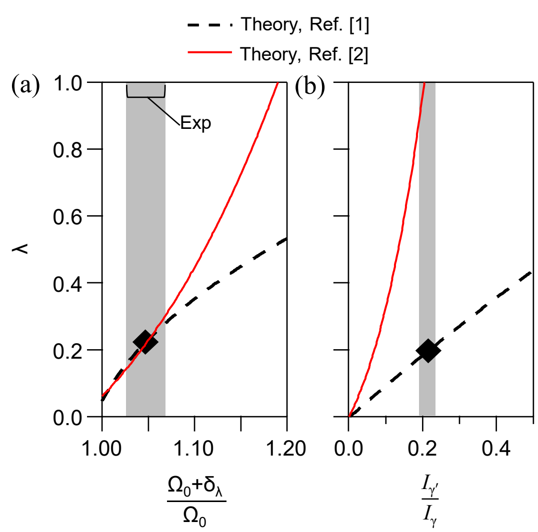

Figure S4. **Extraction of λ based on comparison to theory.** Determination of the electron-phonon coupling constant λ based on the blue shift (a) and replica band intensity (b). Grey regions indicate the experimental uncertainty. Dashed black line is theoretical behavior predicted by Ref. [1], and the red solid line is the equivalent predicted behavior from Ref. [2].

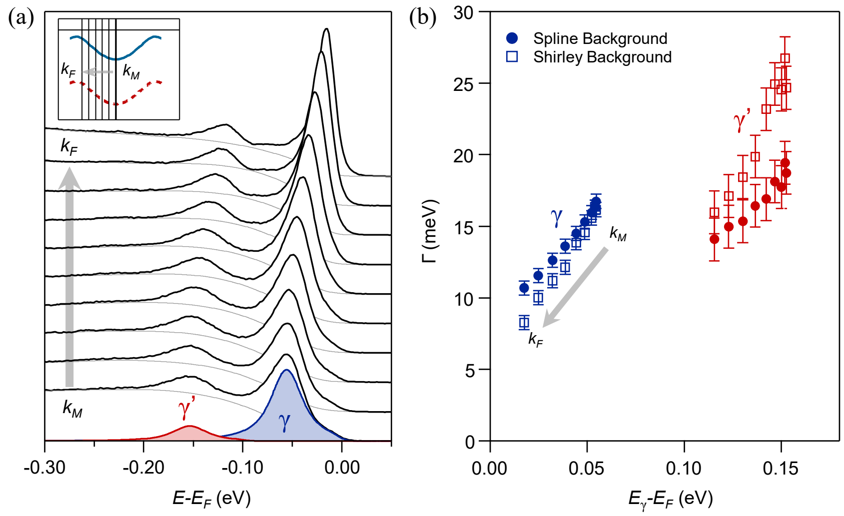

Figure S5. **Influence of background function on quasiparticle lifetime analysis.** (**a**) EDC's spanning the electron pocket dispersion, from the band bottom (k_M) to k_F. Light grey lines indicate a spline fit to the background, and blue and red regions show example fits to the quasiparticle peaks at k_M after background subtraction. (**b**) Comparison of extracted peak half-widths Γ when using either a spline (solid symbols) or Shirley (open symbols) background function.

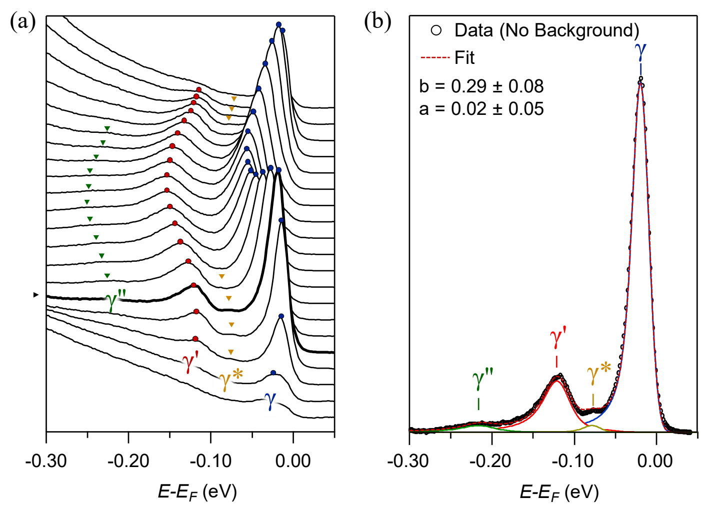

Figure S6. **Fitting of the second-order replica band intensity.** A further consistency check of the probabilities of intrinsic and extrinsic energy losses can be performed by comparing the relative intensities of γ, γ', and γ''. (a) EDCs across M, duplicated from Fig. 3(a) of the main text. k_F is highlighted with a thicker line and arrow marker. (b) Fitting of the spline background-subtracted EDC near k_F (where the weaker γ'' replica band is most visible, black markers) to a four peak model with the intensities of γ' and γ'' restricted to Eq. 7.16 from Steiner, Hochst, and Hufner [3], such that $I_{\gamma^n} = I_0 \left(\frac{e^{-b} b^{-n}}{n!} + a \frac{I_{n-1}}{I_0} \right)$. Blue, orange, red, and green peaks indicate the fitted peak shapes for γ, γ^*, γ', and γ'', respectively. Despite the low overall intensity of the second-order replica, we obtain a reasonable fit with parameters b (corresponding to intrinsic coupling) = 0.29 $\pm$ 0.08 and a (corresponding to extrinsic losses) = 0.02 $\pm$ 0.05, consistent with the expectation for almost exclusively intrinsic replica features.