Supplementary information

Orbital-overlap-driven hybridization in 3d-transition metal perovskite oxides $LaMO_3$ (M = Ti-Ni) and La_2CuO_4

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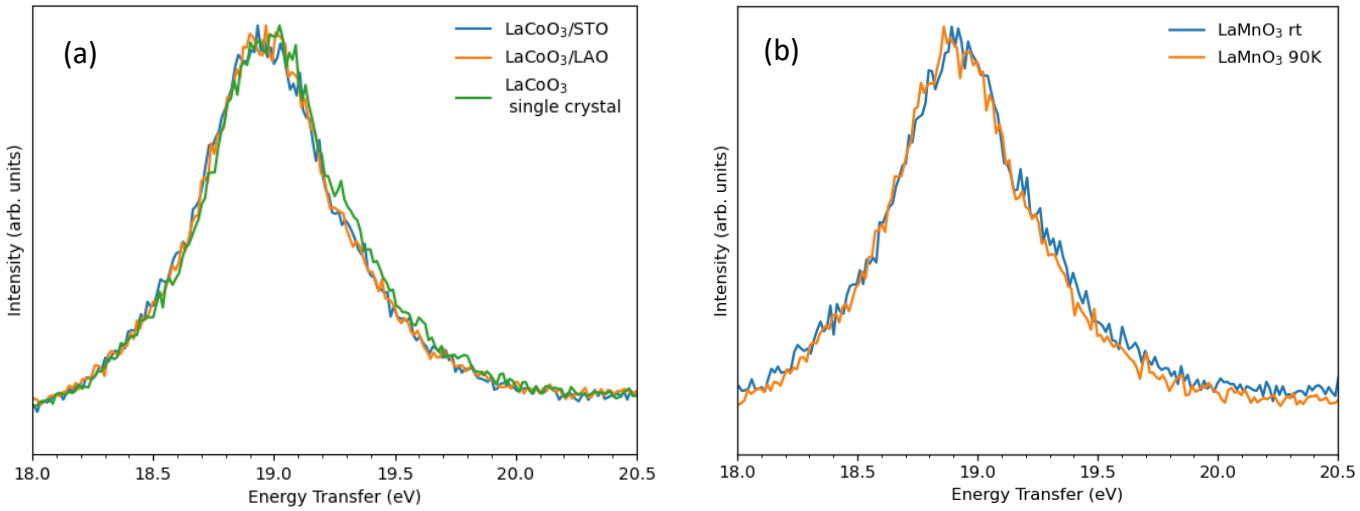

Fig. S1. **Strain and temperature effects on the La $^3D_1$ state observed with resonant inelastic X-ray scattering (RIXS).** (a) RIXS spectra of $LaCoO_3$ single crystal and thin films on different substrates. STO = $SrTiO_3$ substrate (tensile strain), LAO = $LaAlO_3$ substrate (compressive strain). (b) RIXS spectra of $LaMnO_3$ at two temperatures. rt = room temperature.

Table S1. **Fitted result of all compounds.** The model fit is composed of two Voigt profiles representing RIXS $^3D_1$ and $^3D_2$ atomic terms. The gamma (γ, Lorentzian parameter) is fixed to the values from $LaAlO_3$ (γ_{D1} = 0.103 eV, γ_{D2} = 0.169 eV). The Gaussian parameters σ_{D1} and σ_{D2}, representing combined chemical broadening factors, are coupled. The energy separation of the two peaks is fixed to 0.212 eV. The two-Voigt peaks' intensity ratio is fixed to 1. The rest parameters are set free. The standard errors are evaluated based on best model fit with least-squares method.

Sample	$^3D_1$ center (eV)	σ_{D1} (eV)	$^3D_2$ center (eV)	σ_{D2} (eV)
$LaTiO_3$	18.798±0.003	0.268±0.004	19.010±0.003	0.268±0.004
$LaVO_3$	18.818±0.002	0.195±0.004	19.030±0.002	0.195±0.004
$LaCrO_3$	18.820±0.003	0.175±0.004	19.032±0.003	0.175±0.004
$LaMnO_3$	18.835±0.003	0.208±0.004	19.047±0.003	0.208±0.004
$LaFeO_3$	18.855±0.002	0.215±0.004	19.067±0.002	0.215±0.004
$LaCoO_3$	18.876±0.002	0.199±0.003	19.088±0.002	0.199±0.003
$LaNiO_3$	18.813±0.003	0.239±0.004	19.025±0.003	0.239±0.004
La_2CuO_4	18.716±0.002	0.239±0.003	18.928±0.002	0.239±0.003
$LaAlO_3$	18.956±0.001	0.027±0.003	19.168±0.001	0.027±0.003