

Electronic Supplementary information for

The Polarization-Dependent Anisotropic Raman Response of Few-Layer and Bulk WTe_2 under Different Excitation Wavelengths

Qingjun Song,^{a, b} Haifeng Wang,^{c, d} Xiaolong Xu,^{a, b} Xingchen Pan,^{c, d} Yilun Wang,^{a, b} Fengqi
Song,^{c, d} Xiangang Wan,^{c, d*} and Lun Dai^{a, b*}

^aState Key Lab for Mesoscopic Physics and School of Physics, Peking University, Beijing 100871, China.

^bCollaborative Innovation Center of Quantum Matter, Beijing 100871, China.

^cNational Laboratory of Solid State Microstructures, College of Physics, Nanjing University, Nanjing 210093, China.

^dCollaborative Innovation Center of Advanced Microstructures, Nanjing University, Nanjing 210093, China.

* E-mail: xgwan@nju.edu.cn, lundai@pku.edu.cn

Table S1. Selection rules for intermediate states m_1 and m_2 for a given initial state, and for polarization vector aa or bb which both correspond to the excitation of A_g (A' , A_1) phonon mode. These selection rules correspond to the following product of matrix elements:

$$\langle f | H_{e-p} | m_1 \rangle \langle m_1 | H_{e-ph} | m_2 \rangle \langle m_2 | H_{e-p} | i \rangle, \text{ with } |f\rangle = |i\rangle$$

1-layer WTe₂

aa		bb	
$ i\rangle$	$ m_1\rangle = m_2\rangle$	$ i\rangle$	$ m_1\rangle = m_2\rangle$
A_g	B_u	A_g	A_u
B_g	A_u	B_g	B_u
A_u	B_g	A_u	A_g
B_u	A_g	B_u	B_g

N -layer WTe₂ ($N \geq 2$)

aa		bb	
$ i\rangle$	$ m_1\rangle = m_2\rangle$	$ i\rangle$	$ m_1\rangle = m_2\rangle$
A'	A'	A'	A''
A''	A''	A''	A'

Bulk WTe₂

aa		bb	
$ i\rangle$	$ m_1\rangle = m_2\rangle$	$ i\rangle$	$ m_1\rangle = m_2\rangle$
A_1	B_1	A_1	B_2
A_2	B_2	A_2	B_1
B_1	A_1	B_1	A_2
B_2	A_2	B_2	A_1

Table S2. Selection rules for intermediate states m_1 and m_2 for a given initial state i , and polarization vector ab or ba which both correspond to the excitation of B_g (A'' , A_2) phonon from monolayer to bulk WTe_2 , These selection rules correspond to the following product of matrix elements: $\langle f | H_{e-p} | m_1 \rangle \langle m_1 | H_{e-ph} | m_2 \rangle \langle m_2 | H_{e-p} | i \rangle$, with $|f\rangle = |i\rangle$

1-layer WTe_2

ab			ba		
$ i\rangle$	$ m_1\rangle$	$ m_2\rangle$	$ i\rangle$	$ m_1\rangle$	$ m_2\rangle$
A_g	B_u	A_u	A_g	A_u	B_u
B_g	A_u	B_u	B_g	B_u	A_u
A_u	B_g	A_g	A_u	A_g	B_g
B_u	A_g	B_g	B_u	B_g	A_g

N -layer WTe_2 ($N \geq 2$)

ab			ba		
$ i\rangle$	$ m_1\rangle$	$ m_2\rangle$	$ i\rangle$	$ m_1\rangle$	$ m_2\rangle$
A'	A'	A''	A'	A''	A'
A''	A''	A'	A''	A'	A''

Bulk WTe_2

ab			ba		
$ i\rangle$	$ m_1\rangle$	$ m_2\rangle$	$ i\rangle$	$ m_1\rangle$	$ m_2\rangle$
A_1	B_1	B_2	A_1	B_2	B_1
A_2	B_2	B_1	A_2	B_1	B_2
B_1	A_1	A_2	B_1	A_2	A_1
B_2	A_2	A_1	B_2	A_1	A_2