Supporting Information for

Comprehensive understanding of intrinsic mobility and sub-10 nm quantum transportation in Ga_2SSe monolayer

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Table S1. The sound velocities and acoustic energies of the acoustic modes at high symmetry points for Ga_2SSe monolayer

Acoustic mode	Sound velocity (m/s)	Acoustic energy (meV)		
		G	K	M
ZA	204	0	7.24	7.51
TA	2834	0	9.39	8.95
LA	4851	0	13.65	9.92

Table S2. Transport parameters of Ga_2SSe FET with different doping concentrations and transport directions for the gate length of 9 nm

Polarity direction	Doping type	Doping concentration (cm^{-3})	I_{on} (μA/μm)	SS (mV/dec)	I_{on}/I_{off}
Armchair	*n*-type	1×10^{20}	659	64	6.59×10^{3}
		2×10^{20}	1828	68	1.82×10^{4}
		3×10^{20}	2351	72	2.35×10^{4}
		4×10^{20}	2181	77	2.18×10^{4}
		5×10^{20}	2021	81	2.02×10^{4}
	p-type	1×10^{21}	614	88	6.14×10^{3}
		2×10^{21}	1234	95	1.23×10^{4}
		3×10^{21}	1661	94	1.66×10^{4}
		4×10^{21}	1791	95	1.79×10^{4}
		5×10^{21}	1077	97	1.07×10^{4}
Zigzag	*n*-type	6×10^{20}	764	89	7.64×10^{3}
		7×10^{20}	1564	63	1.56×10^{4}
		8×10^{20}	1631	65	1.63×10^{4}
		9×10^{20}	1741	64	1.74×10^{4}
		1×10^{21}	900	98	9.0×10^{3}
	p-type	1×10^{21}	648	88	6.48×10^{3}
		2×10^{21}	1198	97	1.19×10^{4}
		3×10^{21}	1293	100	1.29×10^{4}
		4×10^{21}	1218	105	1.21×10^{4}
		5×10^{21}	954	112	9.54×10^{3}

Table S3. Transport parameters of Ga_2SSe FET with different gate lengths and different gate positions along the armchair direction

L_g (nm)	Gate position	I_{on} (μA/μm)	SS (mV/dec)	I_{on}/I_{off}
5	Top	-	252	-
	Bottom	14	267	1.40×10^2
	Double	88	189	8.80×10^2
7	Top	517	132	5.17×10^3
	Bottom	603	138	6.03×10^3
	Double	1768	104	1.76×10^4
9	Top	1015	87	1.01×10^4
	Bottom	1238	89	1.23×10^4
	Double	2351	72	2.35×10^4

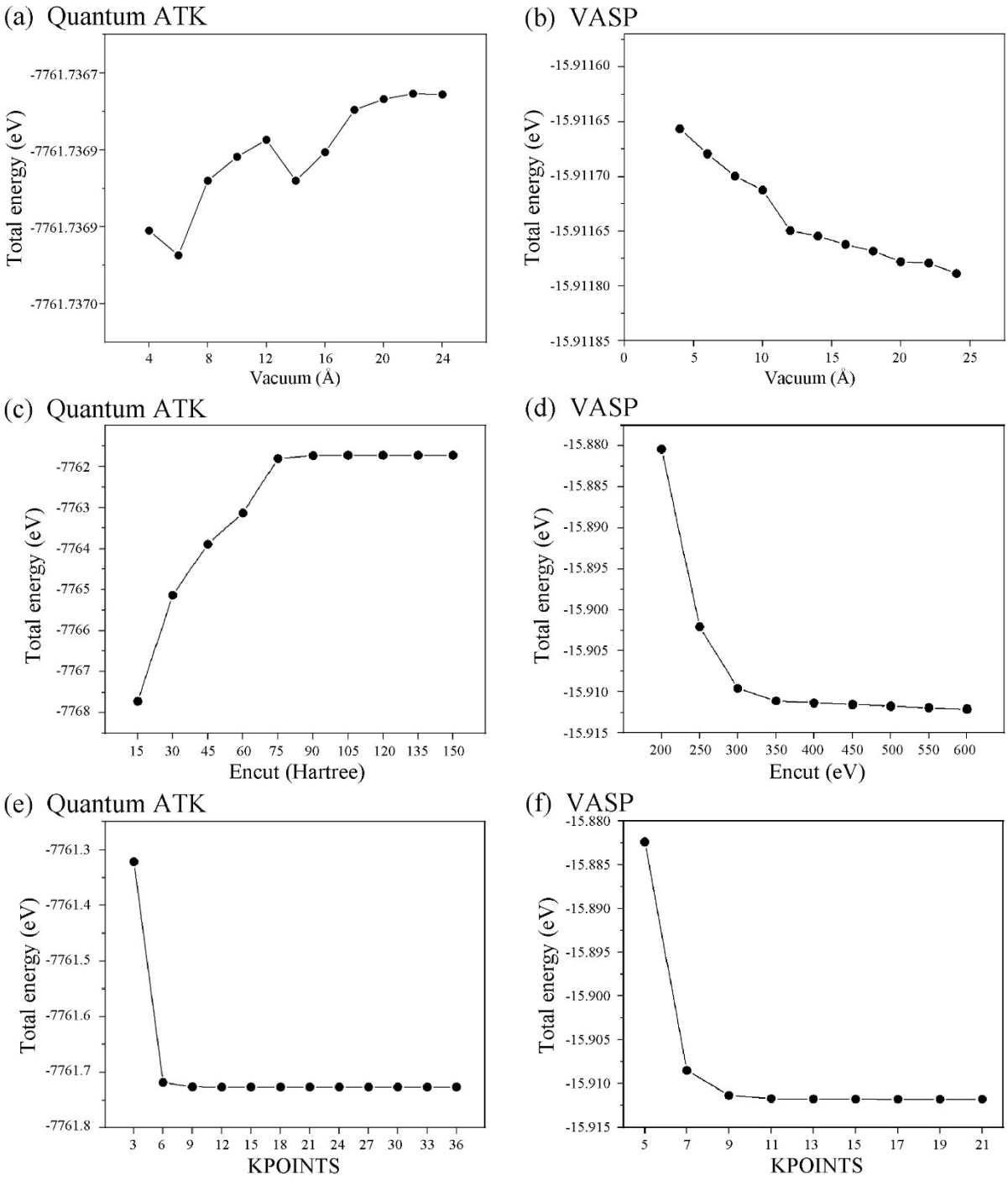

Fig. S1 The (a, b) vacuum thickness, (c, d) cutoff energy and (e, f) KPOINTS mesh test results.

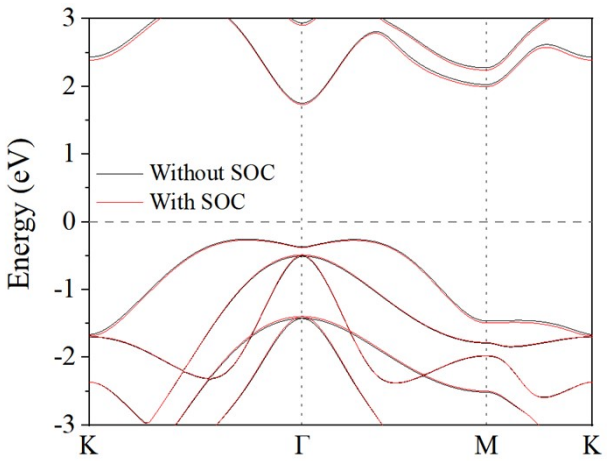

Fig. S2 The band structures for Ga_2SSe monolayer without and with including the spin orbital coupling (SOC) effect. The Fermi energy is set to 0 eV.

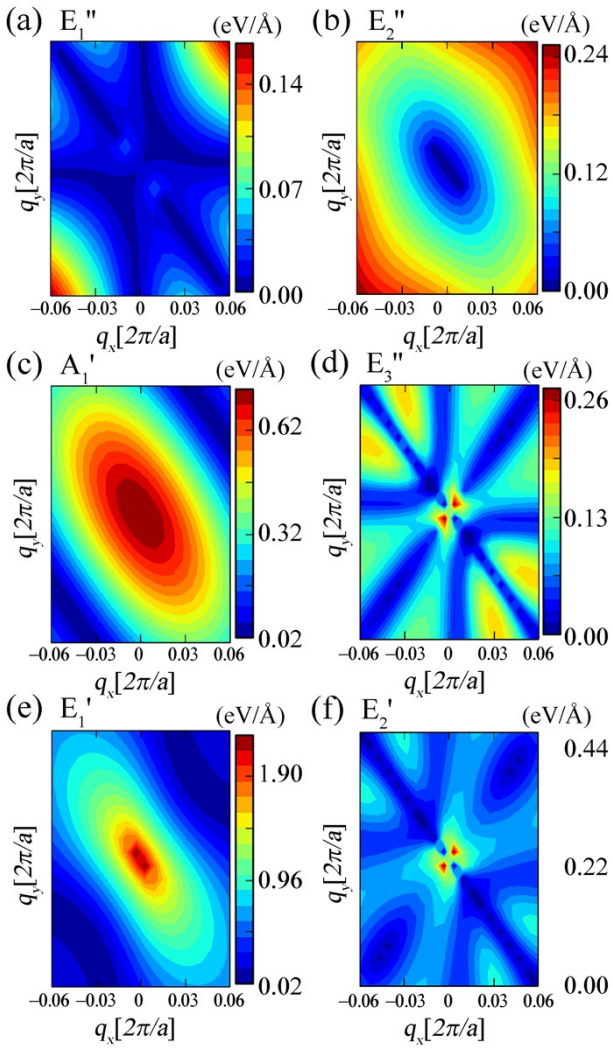

Fig. S3 The electron-phonon interaction matrix elements of the (a) E_1'', (b) E_2'', (c) A_1', (d) E_3'', (e) E_1', (f) E_2' phonon modes.

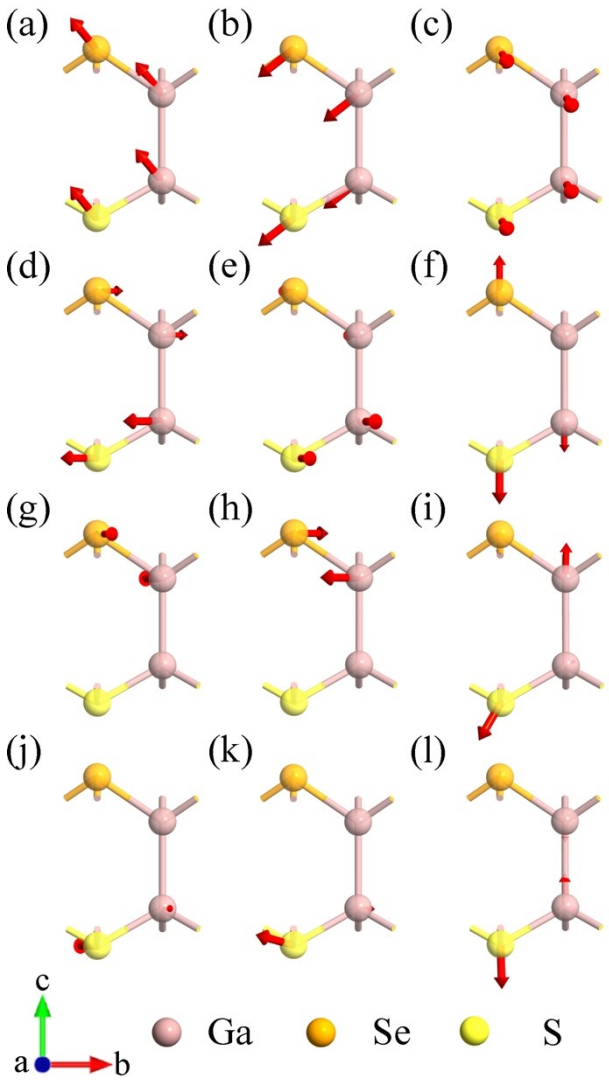

Fig. S4 The atomic dispersions for the (a) ZA, (b) TA, (c) LA, (d) E_1'', (e) E_2'', (f) A_1', (g) E_3'', (h) E_4'', (i) E_1', (j) E_2' (k) A'', (l) A_2' phonon modes.