

Title: Nanoparticles' and atoms' geometrowave potential quantified and unified properties

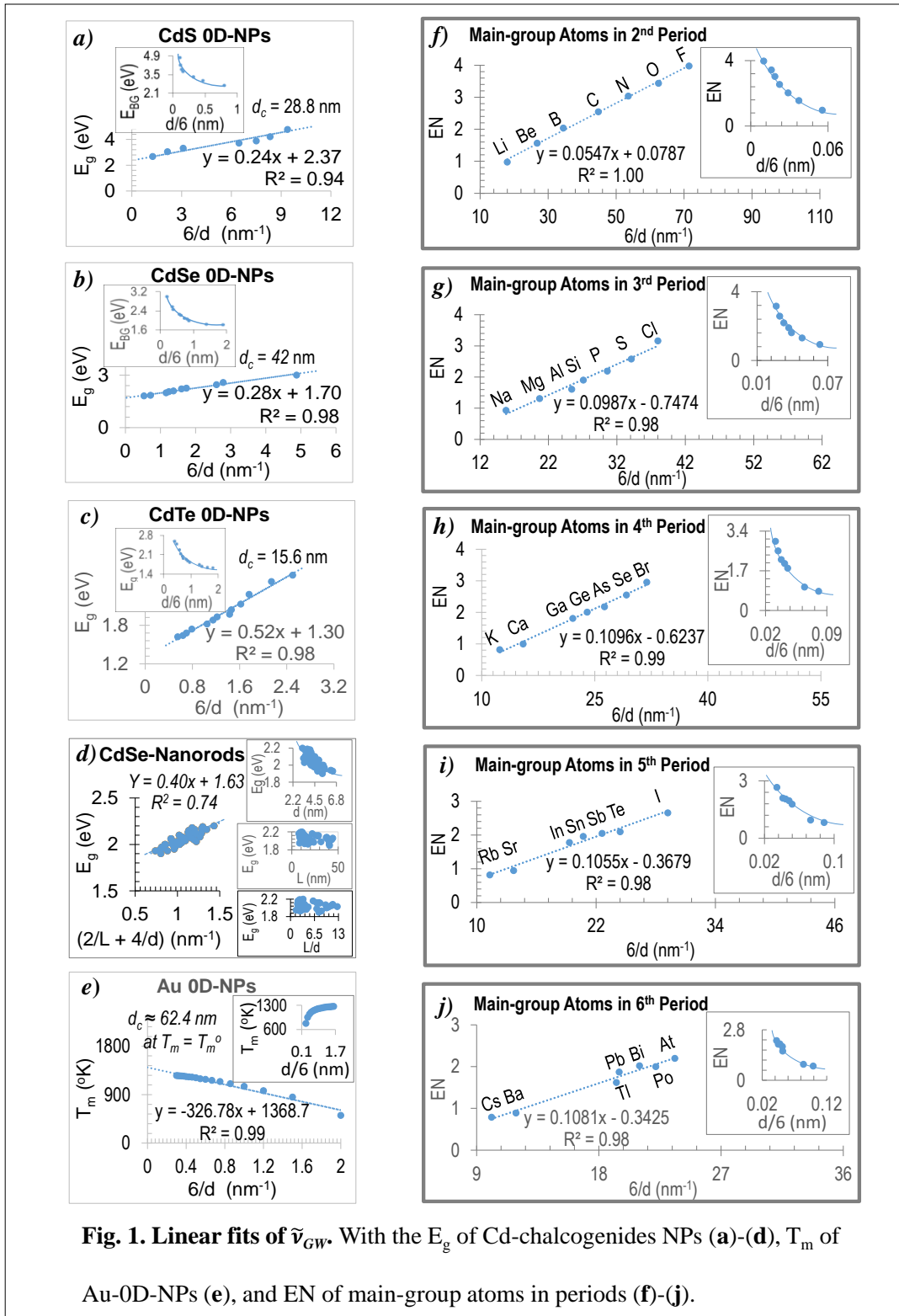
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This work has introduced a geometrowave potential to linearly fit, consistently unify, and quantitatively predict and compare small particles' geometry-quantized properties known and new, which complements de Broglie's matter-wave¹. The knowns cover semiconducting nanoparticle (NP) optical bandgap, gold NP melting point and surface plasmon resonance, and main-group atoms electronegativity, polarizability, and ionization potential. The new properties include NP-surface atoms' layering (like atom-surface electrons'), self-assembled NPs' surface atoms-shared bond (like atoms' surface electrons-shared chemical bond), particles geometrowave potential's generalizability versus atoms unitless electronegativity's periodicity, and NPs-bonded countless compounds nomenclature.

For all zero-dimensional (0D), 1D-, 2D- and 3D-particles of simple shapes (see the **Extended Data Table S1**), let's quantize their geometry-based Surface Area-to-Volume (SA/V) ratio {in the (length⁻¹) unit} into a geometro-wavenumber ($\tilde{\nu}_{GW}$), and their (V/SA) ratio {in the (length) unit} into a geometro-wavelength (λ_{GW}). Accordingly, the geometro-wave potential (i.e. energy) μ_{GW}

$= hc \cdot \tilde{\nu}_{GW} = hc/\lambda_{GW}$, where the c = speed of light, h = Planck constant, and $hc \approx 1.24$ (keV·nm). The μ_{GW} has helped prove (see below) that the pm- and nm-sized particles' "size-dependent" properties are indeed μ_{GW} -dependent i.e. geometry-quantized.

For semiconductive Cd-X (X = S, Se, Te), for example, their 0D-NPs' optical bandgap energies (E_g) (see the **Extended**



Data Table S2)²⁻⁵ fit with their $\tilde{\nu}_{GW}$ (i.e. μ_{GW}/hc) values linearly (**Figs. 1a-1c**) and with

their λ_{GW} (i.e. hc/μ_{GW}) values curvedly (see the insets). The trend of these linear slopes

(i.e. $0.24_{(\text{CdS-NP})} < 0.28_{(\text{CdSe-NP})} < 0.52_{(\text{CdTe-NP})}$) supports that of their $E_{\text{g(Bulk)}}$ values⁶ {i.e. $2.42_{(\text{CdS})} > 1.74_{(\text{CdSe})} > 1.50_{(\text{CdTe})}$ (eV)}, and that of their EN^{7,8}-based bond polarities Cd–S > Cd–Se > Cd–Te. Consistently, every linear equation's intercept $\approx E_{\text{g(bulk)}}$ ⁶.

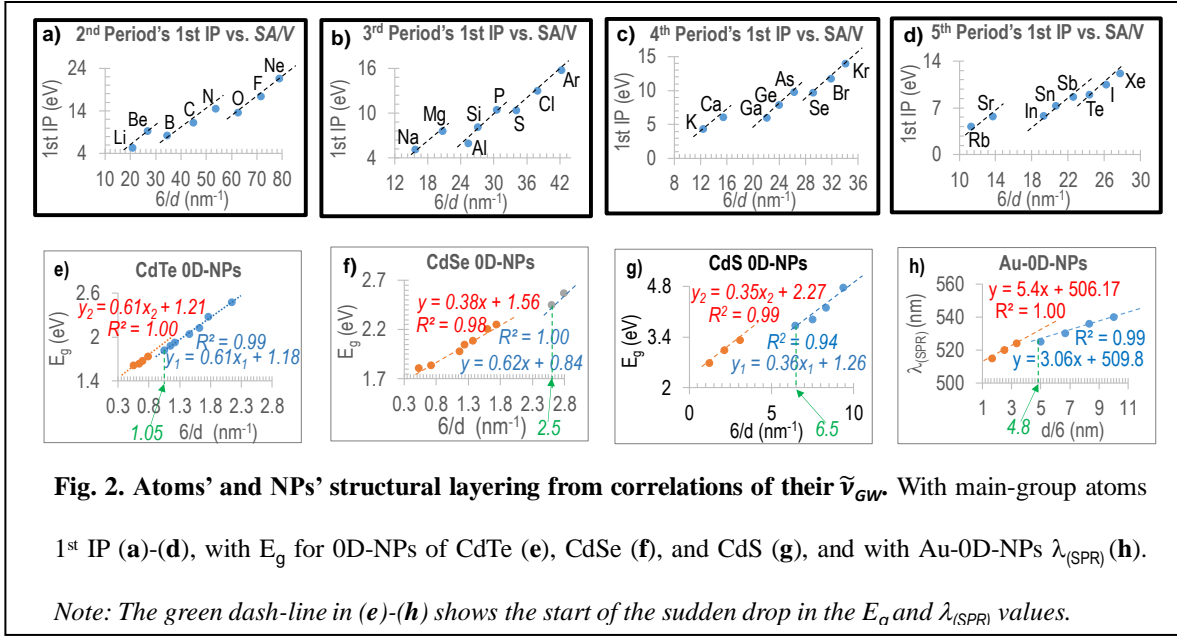
Similarly, CdSe-nanorods' scattering E_{g} data⁹ (see the **Extended Data Table S3**) fit quite linearly with their $\tilde{\nu}_{\text{GW}}$ values (**Fig. 1d**), revealing the μ_{GW} role in the selective interaction with a λ_{photon} . In addition, Au-0D-NPs' melting points¹⁰ (T_{m}) (see the **Extended Data Table S4**) fit linearly with their $\tilde{\nu}_{\text{GW}}$ data (**Fig. 1e**) and curvedly with their λ_{GW} values (the inset), showing the intercept (1368.7 °K) that's about 2.3% off the $T_{\text{m(bulk)}}$ (1337.3 °K)³. The lower T_{m} (i.e. higher μ_{GW}) confirms the smaller NPs surface atoms' lower activation energy that matches a longer $\lambda_{(\text{photon})}$ in heating.

Further, 0D-Au-NPs surface plasmon resonance (SPR) wavelengths (λ_{SPR})¹⁰ and main-group atoms' polarizability⁸ (see the

Extended Data Tables S5-S6) fit linearly with their λ_{GW} (see the **Extended Data Fig. S1**) and curvedly with their $\tilde{\nu}_{\text{GW}}$ values¹¹ (see the two representative insets), respectively. These trends support that the μ_{GW} governs the atom- and NP-surfaces' properties generally.

Consistently, every period of main-group atoms' Pauling electronegativity (EN) data⁷ fit linearly (**Fig. 1, f-j**) with their $\tilde{\nu}_{\text{GW}}$ values and curvedly (the insets) with their λ_{GW} values¹¹ (see the **Extended Data Table S6**). The gap between the *s*- and *p*-orbitals, increasing from **Fig. 1g** to **Fig. 1j** for facilitating the *d*- and then *f*-blocks atoms (omitted here for clarity), revealed the atoms' E_{GW} -generalized and (EN)-complemented periodicity (**Table 1**), and the atoms and NPs layering surfaces' new properties below.

Firstly, main-group atoms' $\tilde{\nu}_{\text{GW}}$ fits linearly with their First Ionization Potential (critical in Mulliken EN¹², see the **Extended Data Table S6**) to quantify the atom-surface electrons' μ_{GW} -quantized layering i.e. in the *s*-



orbital first, and then the p -orbitals before and after the electrons half-fill (Figs. 2a-2d). The s - and p -orbitals' such geometrization and quantization in the Figs. 2a-2d match that in the Figs. 1f-1j. Further, the transition metal cations' $\tilde{\nu}_{GW}$ fits linearly with their ionization potential⁸ (see the Extended Data Table S7 and the Extended Data Fig. S2), showing the d -orbital size's negligible change before and after the electrons half-fill.

Likewise, zooming in the Figs. 1a-1c has revealed the NPs' sudden (i.e. quantized) E_g drop (see the green dash-lines) as CdTe-NP's (Fig. 2e) < CdSe-NP's (Fig. 2f) < CdS-NP's (Fig. 2g). This supports the PbSe-0D-

NPs' negligible E_g drop (see the Extended Data Table S8 and the Extended Data Fig. S3), since the $E_{g(bulk-PbSe)} \approx 0.7$ (eV)⁶ << $E_{g(bulk-CdTe)}$. The E_g sudden drop supports the NP-surface atoms' E_{GW} -quantized layering, like atom-surface electrons' (Figs. 2a-2d), revealing the NPs' atomistic nature¹³ which helps expand Bohr's atomic model in the quantum mechanics (QM).

Moreover, zooming in the Extended Data Fig. S1a has disclosed the Au-0D-NPs' sudden drop of (λ_{SPR}) when $\lambda_{GW} < 4.8$ (nm) (Fig. 2h). Apparently, the Au-NPs' surface atoms layer likewise (Figs. 2e-2g). The NPs' atomistic nature (Figs. 2e-2h) supports

Table 1. Periodicities of Atoms $\tilde{\nu}_{GW}$																																															
H 0.106 56.6 2.20																	He 0.062 96.8																														
Li 0.234 20.6 0.98	Be 0.224 26.8 1.57															B 0.174 34.5 2.04	C 0.134 44.8 2.55	N 0.112 53.6 3.04	O 0.096 62.5 3.44	F 0.084 71.4 3.98	Ne 0.076 78.9																										
<div style="display: flex; justify-content: space-between; align-items: flex-start;"> <div style="border: 1px solid black; padding: 2px;"> La 0.308 19.5 1.10 </div> <div> Atomic Symbol Atomic diameter* (unit: (nm)) $\tilde{\nu}_{GW}$ (unit: nm⁻¹) Pauling's EN** </div> </div> <p>*Atomic diameters data source: https://en.wikipedia.org/wiki/Atomic_radii_of_the_elements_(data_page) (Jan-8-2019).</p> <p>**Pauling's EN data source: Lide, D. R. <i>CRC Handbook of Chem. and Phys.</i> (CRC Press, Boca Raton, FL, 2000).</p>																																															
Na 0.380 15.8 0.93	Mg 0.290 20.7 1.31	K 0.486 12.3 0.82	Ca 0.388 15.5 1.00	Sc 0.368 16.3 1.36	Ti 0.352 17.0 1.54	V 0.342 17.5 1.6	Cr 0.332 18.1 1.66	Mn 0.322 18.6 1.55	Fe 0.312 19.2 1.83	Co 0.304 19.7 1.88	Ni 0.298 20.1 1.91	Cu 0.290 20.7 1.90	Zn 0.282 21.3 1.65	Ga 0.272 22.1 1.81	Ge 0.250 24.0 2.01	As 0.228 26.3 2.18	Se 0.206 29.1 2.55	Br 0.188 31.9 2.96	Kr 0.176 34.1																												
Rb 0.530 11.3 0.82	Sr 0.438 13.7 0.95	Y 0.424 14.2 1.22	Zr 0.412 14.7 1.33	Nb 0.396 15.2 1.6	Mo 0.380 15.8 2.16	Tc 0.366 16.4 2.10	Ru 0.356 16.9 2.2	Rh 0.346 17.3 2.28	Pd 0.338 17.8 2.20	Ag 0.330 18.2 1.93	Cd 0.322 18.6 1.69	In 0.312 19.2 1.78	Sn 0.290 20.7 1.96	Sb 0.266 22.6 2.05	Te 0.246 24.4 2.1	I 0.230 26.1 2.66	Xe 0.216 27.8 2.60																														
Cs 0.596 10.1 0.79	Ba 0.506 11.9 0.89	La 0.390 15.4 1.10	Hf 0.416 14.4 1.3	Ta 0.400 15.0 1.5	W 0.386 15.5 1.7	Re 0.376 16.0 1.9	Os 0.370 16.2 2.2	Ir 0.360 16.7 2.2	Pt 0.354 16.9 2.2	Au 0.348 17.2 2.4	Hg 0.342 17.5 1.9	Tl 0.312 15.8 1.8	Pb 0.308 19.5 1.8	Bi 0.286 21.0 1.9	Po 0.270 22.2 2.0	At 0.300 20.0 2.2	Rn 0.240 25.0																														
<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td>La 0.390 15.4 1.10</td> <td>Ce 0.370 16.2 1.12</td> <td>Pr 0.370 16.2 1.13</td> <td>Nd 0.370 16.2 1.1</td> <td>Pm 0.370 16.2 1.17</td> <td>Sm 0.370 16.2 1.17</td> <td>Eu 0.370 16.7 1.20</td> <td>Gd 0.360 17.1 1.20</td> <td>Tb 0.350 17.1 1.22</td> <td>Dy 0.350 17.1 1.22</td> <td>Ho 0.350 17.1 1.23</td> <td>Er 0.350 17.1 1.24</td> <td>Tm 0.350 17.1 1.25</td> <td>Yb 0.350 17.1 1.25</td> <td>Lu 0.350 17.1 1.0</td> </tr> <tr> <td>Ac 0.390 15.4 1.1</td> <td>Th 0.360 16.7 1.3</td> <td>Pa 0.360 16.7 1.5</td> <td>U 0.350 17.1 1.7</td> <td>Np 0.350 17.1 1.3</td> <td>Pu 0.350 17.1 1.3</td> <td>Am 0.350 17.1 1.3</td> <td>Cm 0.238 25.2</td> <td>Bk 0.34 17.6</td> <td>Cf 0.372 16.1</td> <td>Es 0.372 16.1</td> <td>Fm 0.334 18.0</td> <td>Md 0.346 17.3</td> <td>No 0.332 18.1</td> <td>Lr 0.322 18.1</td> </tr> </table>																		La 0.390 15.4 1.10	Ce 0.370 16.2 1.12	Pr 0.370 16.2 1.13	Nd 0.370 16.2 1.1	Pm 0.370 16.2 1.17	Sm 0.370 16.2 1.17	Eu 0.370 16.7 1.20	Gd 0.360 17.1 1.20	Tb 0.350 17.1 1.22	Dy 0.350 17.1 1.22	Ho 0.350 17.1 1.23	Er 0.350 17.1 1.24	Tm 0.350 17.1 1.25	Yb 0.350 17.1 1.25	Lu 0.350 17.1 1.0	Ac 0.390 15.4 1.1	Th 0.360 16.7 1.3	Pa 0.360 16.7 1.5	U 0.350 17.1 1.7	Np 0.350 17.1 1.3	Pu 0.350 17.1 1.3	Am 0.350 17.1 1.3	Cm 0.238 25.2	Bk 0.34 17.6	Cf 0.372 16.1	Es 0.372 16.1	Fm 0.334 18.0	Md 0.346 17.3	No 0.332 18.1	Lr 0.322 18.1
La 0.390 15.4 1.10	Ce 0.370 16.2 1.12	Pr 0.370 16.2 1.13	Nd 0.370 16.2 1.1	Pm 0.370 16.2 1.17	Sm 0.370 16.2 1.17	Eu 0.370 16.7 1.20	Gd 0.360 17.1 1.20	Tb 0.350 17.1 1.22	Dy 0.350 17.1 1.22	Ho 0.350 17.1 1.23	Er 0.350 17.1 1.24	Tm 0.350 17.1 1.25	Yb 0.350 17.1 1.25	Lu 0.350 17.1 1.0																																	
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smaller NPs' stronger inter-bonding in self-assemblies¹⁴⁻¹⁹ via geometrically "sharing" their surface atoms (see the **Extended Data Fig. S4**), like smaller atoms' stronger inter-bonding via sharing a higher percentage of their surface electrons. This indicates that a NP acts like a super atom, which again helps expand Bohr's atomic model (**Figs. 2a-2d**).

In summary, the new geometrowave potential has been proven generally useful to complement de Broglie's matter-wave (i.e.

QM), and quantitatively predict and compare and consistently unify the NPs and atoms geometry-quantized properties known and new. The new properties, including the NPs' surface-atoms layering, inter-NP bonding, and atoms' EN-complemented and E_{GW} -generalized periodicity, have naturally helped derive new basics for geometrophysics, geometrochemistry and geometrochemical biology, which should be detailed separately^{20,21}.

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SUPPLEMENATRY DATA.

I. Extended Data Tables S1–S8.




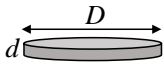




II. Extended Data Figures S1–S3.

Title: **Nanoparticles' and atoms' geometrowave potential quantified and unified properties**

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I. Extended Data Tables.

1). Extended Data Table S1.

Table S1. Simple-Shape Particles' $\tilde{\nu}_{GW}$ and Point Group of Symmetry					
	Shape	Surface-Area (SA)	Volume (V)	$\tilde{\nu}_{GW} (= SA/V)$	PntGrpSym
0D	 d	πd^2	$\pi d^3/6$	$(6/d)^*$	R_3
1D	 L d	$4dL + 2d^2$	$d^2 L$	$(4/d + 2/L)^{**}$ or $(4/d)^{**}$ if $d \ll L$	D_{2d}
	 L d	$\pi d^2/2 + \pi dL$	$\pi d^2 L/4$	$(4/d + 2/L)^{**}$ or $(4/d)^{**}$ if $d \ll L$	$D_{\infty d}$
2D	 D d	$\pi D^2/2 + d\pi D$	$d\pi D^2/4$	$2/d + 4/D;$ or $2/d$ if $d \ll D$	$D_{\infty d}$
	 L L d	$2(aL + aL + L^2)$	aL^2	$2/d + 2/L + 2/L;$ or $2/d$ if $d \ll L$	D_{4d}
3D	 d	$6d^2$	d^3	$(6/d)^*$	O_h
	 d	$2 \times 3^{1/2} d^2$	$2^{1/2} d^3/3$	$3 \times 6^{1/2}/d$	O_h
	 d	$1.732d^2$	$0.118d^3$	$14.678/d$	T_d

*The spherical and cubic particles share the same $\tilde{\nu}_{GW}$ formula;
 **The two 1D-particles share the same $\tilde{\nu}_{GW}$ formula.

2). Extended Data Table S2.

Table S2. Semiconducting 0D-NPs E_g and $\tilde{\nu}_{GW}$

(a). CdS 0D-NP			(b). CdSe 0D-NP			(c). CdTe 0D-NP		
E_{BG} (eV)	d/6 (nm)	6/d (nm ⁻¹)	E_{BG} (eV)	d/6 (nm)	6/d (nm ⁻¹)	E_{BG} (eV)	d/6 (nm)	6/d (nm ⁻¹)
4.78	0.11	9.4	3.00	0.205	4.9	2.58	0.4	2.5
4.22	0.12	8.3	2.57	0.358	2.8	2.48	0.47	2.1
3.89	0.14	7.5	2.45	0.393	2.6	2.28	0.57	1.8
3.72	0.16	6.5	2.25	0.575	1.7	2.13	0.62	1.6
3.32	0.32	3.1	2.21	0.624	1.6	2.04	0.68	1.5
3.05	0.47	2.1	2.09	0.727	1.4	1.97	0.71	1.4
2.68	0.80	1.3	2.05	0.807	1.2	1.93	0.82	1.2
			1.98	0.860	2.2	1.88	0.87	1.2
			1.84	1.39	0.72	1.82	0.95	1.1
			1.61	1.88	0.53	1.74	1.3	0.79
						1.68	1.4	0.70
						1.64	1.6	0.64
						1.62	1.8	0.55

3). Extended Data Table S3.

Table S3. Au-0D-NPs melting points and $\tilde{\nu}_{GW}$

d/6 (nm)	6/d (nm ⁻¹)	T_m (°K)	d/6 (nm)	6/d (nm ⁻¹)	T_m (°K)
0.30	3.330	773	1.05	5.714	1223
0.38	15.79	953	1.13	5.301	1233
0.47	12.77	1043	1.22	4.918	1243
0.55	10.91	1098	1.30	4.615	1251
0.64	9.375	1138	1.38	4.349	1255
0.72	8.333	1163	1.45	4.138	1256
0.80	7.500	1183	1.53	3.922	1262
0.88	6.818	1198	1.62	3.704	1266
0.95	6.316	1208			

4). Extended Data Table S4.

E_g (eV)	d (nm)	L (nm)	L/d	(SA/V)* (nm ⁻¹)	E_g (eV)	d (nm)	L (nm)	L/d	(SA/V)* (nm ⁻¹)
2.20	3.2	11.0	3.4	1.4	2.07	4.3	8.7	2.0	1.2
2.08	3.3	37.8	12	1.27	2.08	4.3	16.4	3.8	1.1
2.03	3.4	43.1	13	1.23	2.10	4.4	8.6	2.0	1.1
2.11	3.5	28.0	8.0	1.2	1.98	4.4	31.5	7.2	0.97
2.05	3.5	38.5	11	1.2	2.10	4.5	15.3	3.4	1.0
2.17	3.6	11.5	3.2	1.3	2.02	4.6	19.8	4.3	0.97
2.16	3.6	22.1	6.1	1.2	1.97	4.6	19.8	4.3	0.97
2.16	3.7	7.6	2.1	1.3	2.03	4.8	12.4	2.6	0.99
2.19	3.7	9.2	2.5	1.3	2.03	4.8	19.4	4.0	0.94
2.12	3.7	26.1	7.1	1.2	1.93	4.8	40.4	8.4	0.88
2.12	3.7	28.8	7.8	1.2	2.06	4.9	18.4	3.8	0.93
2.12	3.8	8.6	2.3	1.3	2.06	4.9	18.9	3.9	0.92
2.07	3.9	37.2	9.5	1.1	1.99	5.1	12.0	2.4	0.95
2.06	3.9	44.3	11	1.1	2.00	5.2	11.4	2.2	0.94
2.12	4.0	9.7	2.4	1.2	2.00	5.2	22.2	4.3	0.86
2.18	4.0	11.6	2.9	1.2	1.90	5.3	40.8	7.7	0.80
2.02	4.0	41.3	10	1.1	2.00	5.4	18.2	3.4	0.85
2.15	4.1	12.7	3.1	1.1	1.95	5.5	8.5	1.6	0.96
2.13	4.1	13.4	3.3	1.1	1.96	5.5	18.4	3.4	0.84
2.04	4.1	16.9	4.1	1.1	1.97	5.5	23.6	4.3	0.81
2.00	4.1	40.2	9.8	1.0	1.94	6.2	14.0	2.3	0.79
2.06	4.2	16.5	3.9	1.1	1.93	6.4	17.6	2.8	0.74
2.02	4.2	20.2	4.8	1.1					

* (SA/V) = (2/L) + (4/d), from the Table 1

5). Extended Data Table S5.

d (nm)	$\lambda_{QGD} = d/6$ (nm)	$\tilde{\nu}_{QGD} = 6/d$ (nm ⁻¹)	λ_{SPR} (nm)
10	1.67	0.60	517.5
15	2.5	0.40	520
20	3.33	0.30	524
30	5	0.20	526
40	6.67	0.15	530
50	8.33	0.12	535
60	10	0.10	540
80	13.33	0.075	553
100	16.67	0.060	572

6). Extended Data Table S6.

Table S6. Main-group atoms polarizability, electronegativity, 1st IP, and $\tilde{\nu}_{GW}$

Atom	Polarizability ⁽³⁾ (10 ⁻²⁴ cm ³)	EN ⁽³⁾	1st IP ⁽³⁾ (eV)	d/6 ^{(3),(11)} (nm)	6/d (nm ⁻¹)	Atom	Polarizability ⁽³⁾ (10 ⁻²⁴ cm ³)	EN ⁽³⁾	1st IP ⁽³⁾ (eV)	d/6 ^{(3),(11)} (nm)	6/d (nm ⁻¹)
H	0.667	2.2	13.598	0.0177	56.6	Ge	6.07	2.01	7.899	0.0417	24.0
He	0.205		24.587	0.0103	96.8	As	4.31	2.18	9.789	0.038	26.3
Li	24.3	0.98	5.391	0.0555	18.0	Se	3.72	2.55	9.752	0.0342	29.2
Be	5.6	1.57	9.322	0.0373	26.8	Br	3.05	2.96	11.814	0.0313	31.9
B	3.03	2.04	8.298	0.029	34.5	Kr	2.48		14.0	0.0293	34.1
C	1.76	2.55	11.26	0.0223	44.8	Rb	47.3	0.82	4.177	0.0885	11.3
N	1.1	3.04	14.534	0.0187	53.6	Sr	27.6	0.95	5.695	0.073	13.7
O	0.802	3.44	13.618	0.016	62.5	In	10.2	1.78	5.786	0.0518	19.3
F	0.557	3.98	17.423	0.01	71.5	Sn	7.7	1.96	7.344	0.0483	20.7
Ne	0.39		21.565	0.0127	78.9	Sb	6.6	2.05	8.608	0.0442	22.6
Na	24.08	0.93	5.139	0.0633	15.8	Te	5.5	2.1	9.01	0.041	24.4
Mg	10.6	1.31	7.646	0.0483	20.7	I	5.35	2.66	10.451	0.0342	29.2
Al	6.8	1.61	5.986	0.0393	25.4	Xe	2.6	2.6	12.13	0.036	27.8
Si	5.38	1.90	8.152	0.0369	27.1	Cs	59.6	0.79	3.894	0.099	10.1
P	3.63	2.19	10.487	0.0327	30.6	Ba	39.7	0.89	5.212	0.084	11.9
S	2.9	2.58	10.36	0.0293	34.1	Tl	7.6	1.8	6.108	0.0623	15.8
Cl	2.18	3.16	12.968	0.0263	38.0	Pb	6.8	1.8	7.417	0.0513	19.5
Ar	1.62		15.76	0.0236	42.3	Bi	7.4	1.9	7.286	0.0476	21.0
K	43.3	0.82	4.341	0.0806	12.4	Po	6.8	2.0	8.417	0.045	22.2
Ca	22.8	1.00	6.113	0.0645	15.5	At	6.0	2.2		0.0424	23.6
Ga	8.12	1.81	5.999	0.0452	22.1	Rn	2.2		10.749	0.040	25.0

Note: The superscripts (3) and (11) represent the References #3 and #11.

7). Extended Data Table S7.

Table S7. High-valent monoatomic cations $\tilde{\nu}_{GW}$ and ionization potentials

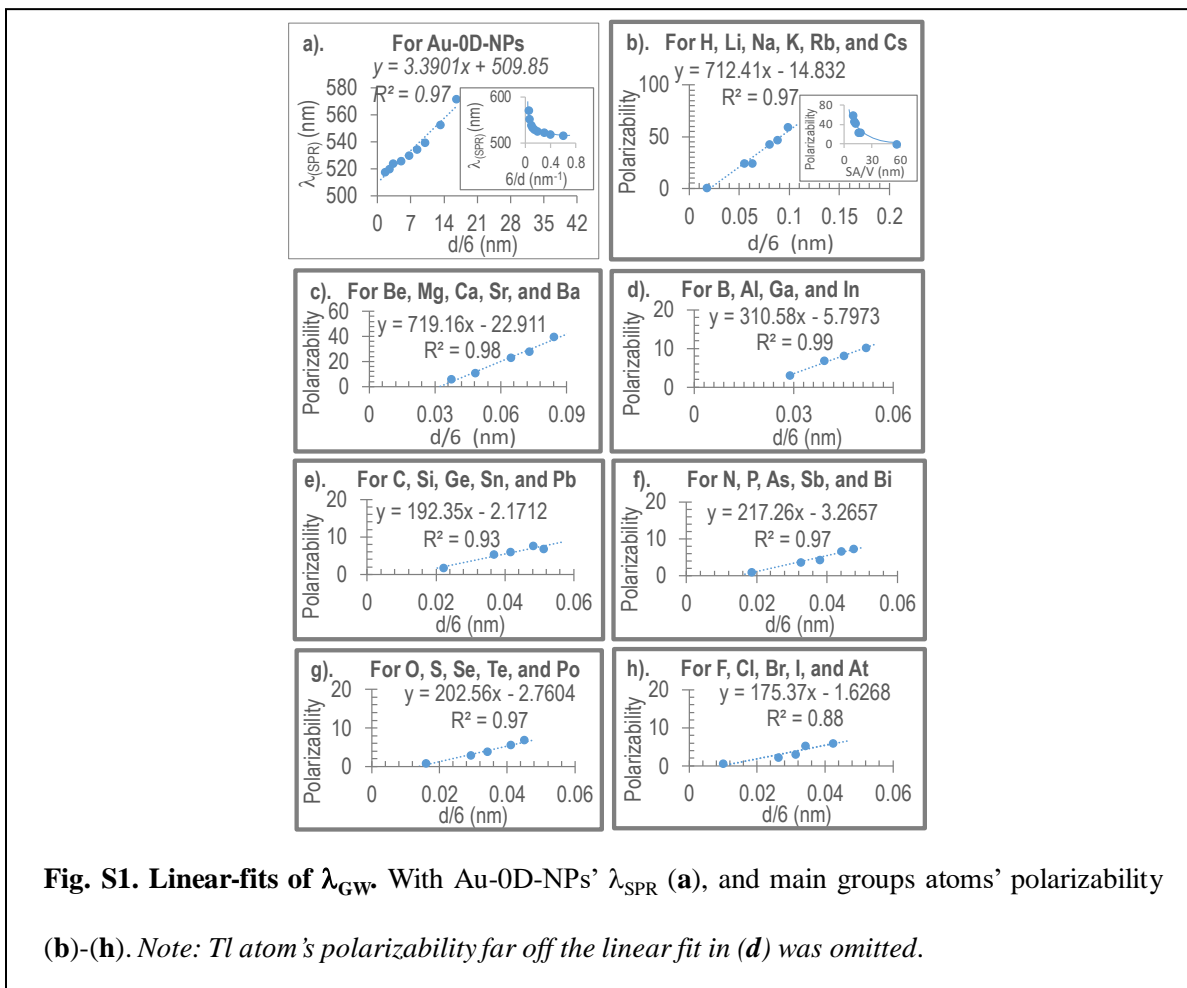
<u>Cation</u>	<u>d/2 (nm)</u>	<u>6/d (nm⁻¹)</u>	<u>IP (eV)</u>	<u>Cation</u>	<u>d/2 (nm)</u>	<u>6/d (nm⁻¹)</u>	<u>IP (eV)</u>
V (II)	0.079	37.97	29.311	Mn (II)	0.083	36.14	33.668
V (III)	0.064	46.88	46.71	Mn (III)	0.058	51.72	51.2
V (IV)	0.058	51.72	65.28	Mn (IV)	0.053	56.6	72.4
V (V)	0.054	55.56	128.13	Mn (V)	0.033	90.91	95.6
				Mn (VI)	0.026	115.38	119.203
Cr (II)	0.073	41.1	30.96	Mn (VII)	0.025	120	194.5
Cr (III)	0.062	48.39	49.16				
Cr (IV)	0.055	54.55	90.635	Mo (III)	0.069	43.48	46.4
Cr (VI)	0.044	68.18	160.18	Mo (IV)	0.065	46.15	54.49
				Mo (V)	0.061	49.18	68.83
				Mo (VI)	0.059	50.85	125.67

8). Extended Data Table S8.

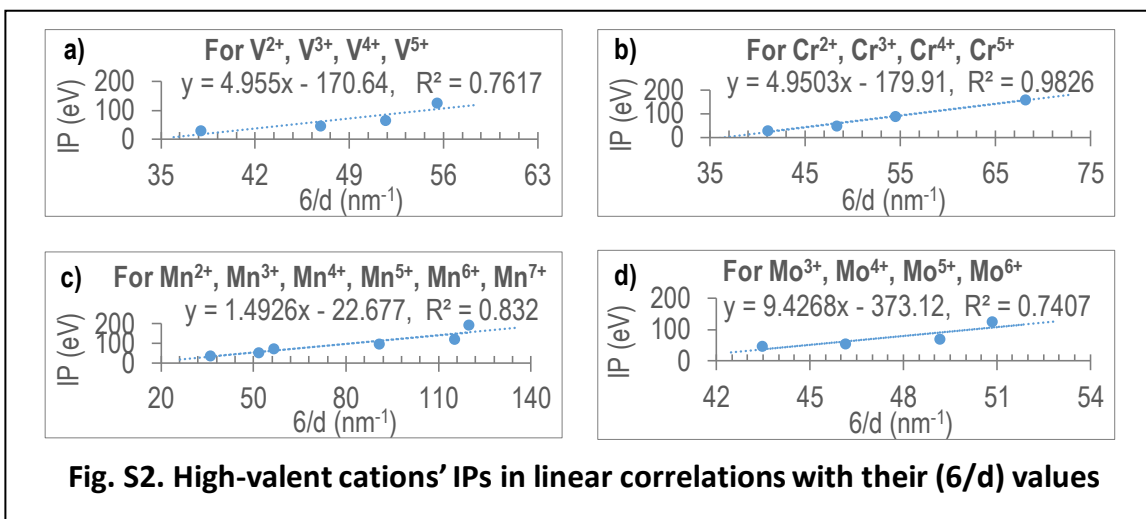
Table S8. PbSe 0D-NP	
E_g (eV)	$6/d$ (nm^{-1})
0.833	1.18
0.967	1.40
1.077	1.58
1.243	1.88
1.656	2.61

II. Extended Data Figures:

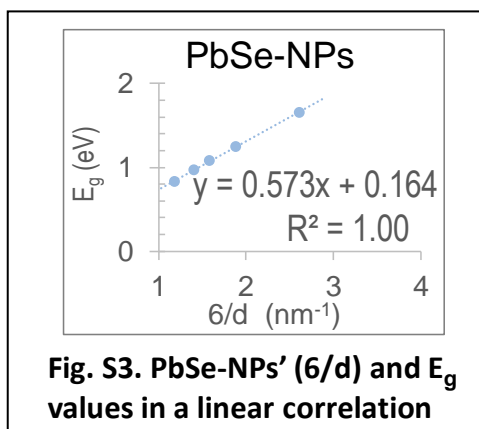
1). Extended Data Fig. S1.



2). Extended Data Fig. S2.



3). Extended Data Fig. S3.



4). Extended Data Fig. S4.

