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Ferromagnetic spin correlations in a few-fermion system

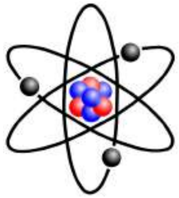
G.J. Conduit, P.O. Bugnion

Phys. Rev. A **87**, 060502(R) (2013)

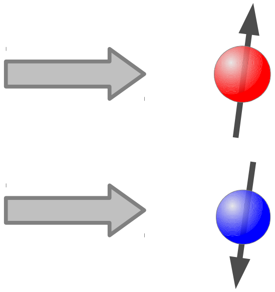
Phys. Rev. A **88**, 013601 (2013)

arXiv:1305.3717, accepted for Phys. Rev. Lett.

Experimental setup



^{6}Li atom

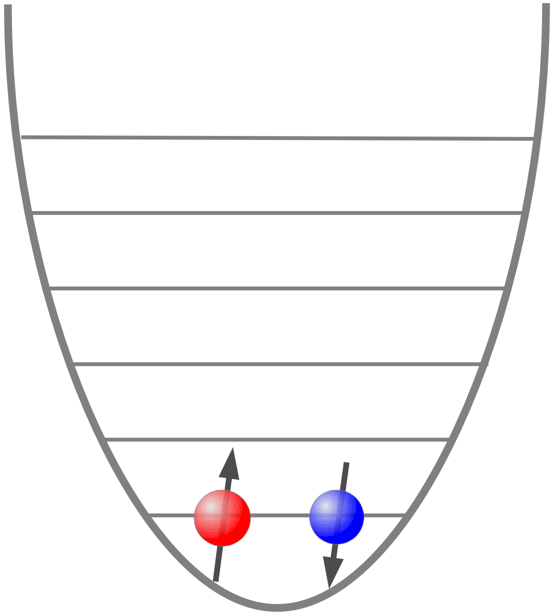


$|F = 1/2, m_F = 1/2\rangle$ → Up spin electron

$|F = 1/2, m_F = -1/2\rangle$ → Down spin electron

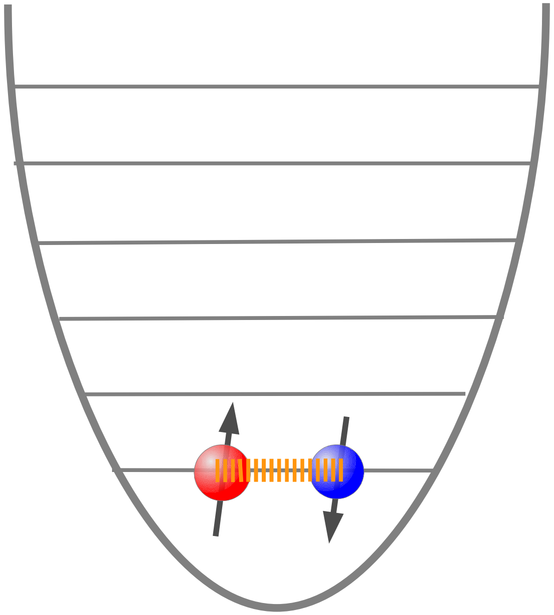
$$\hat{H} = -\frac{\nabla^2}{2} + g n_\uparrow(\vec{r}) n_\downarrow(\vec{r})$$

Two distinguishable fermions

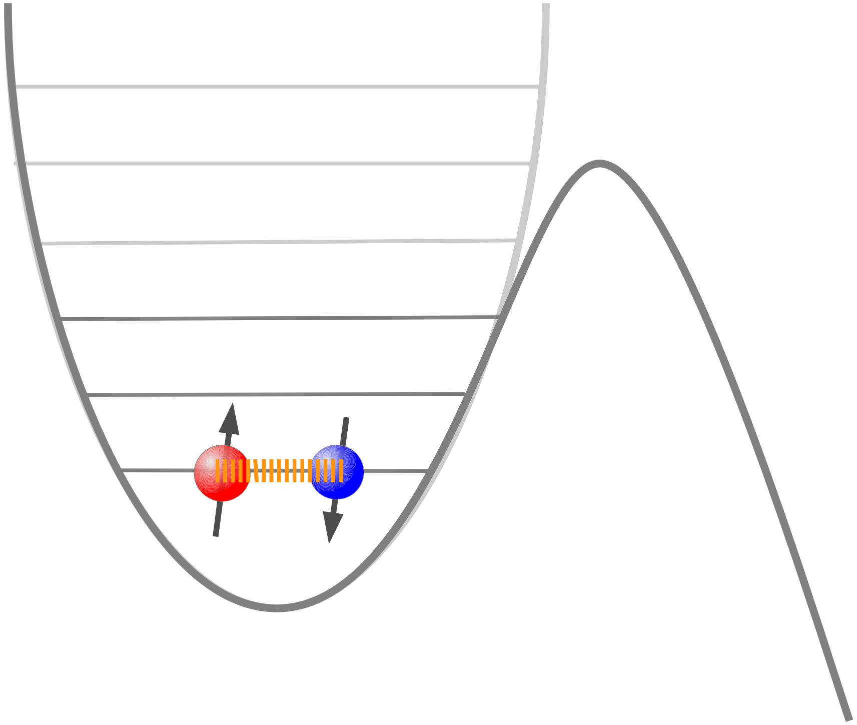


Zürn PRL 108 075303 (2012)

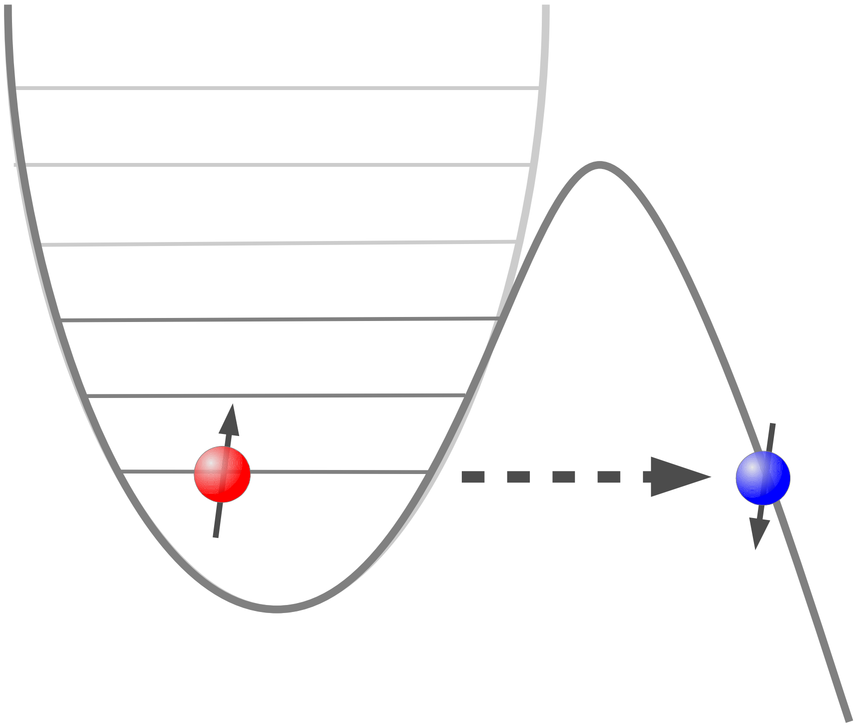
Two distinguishable fermions



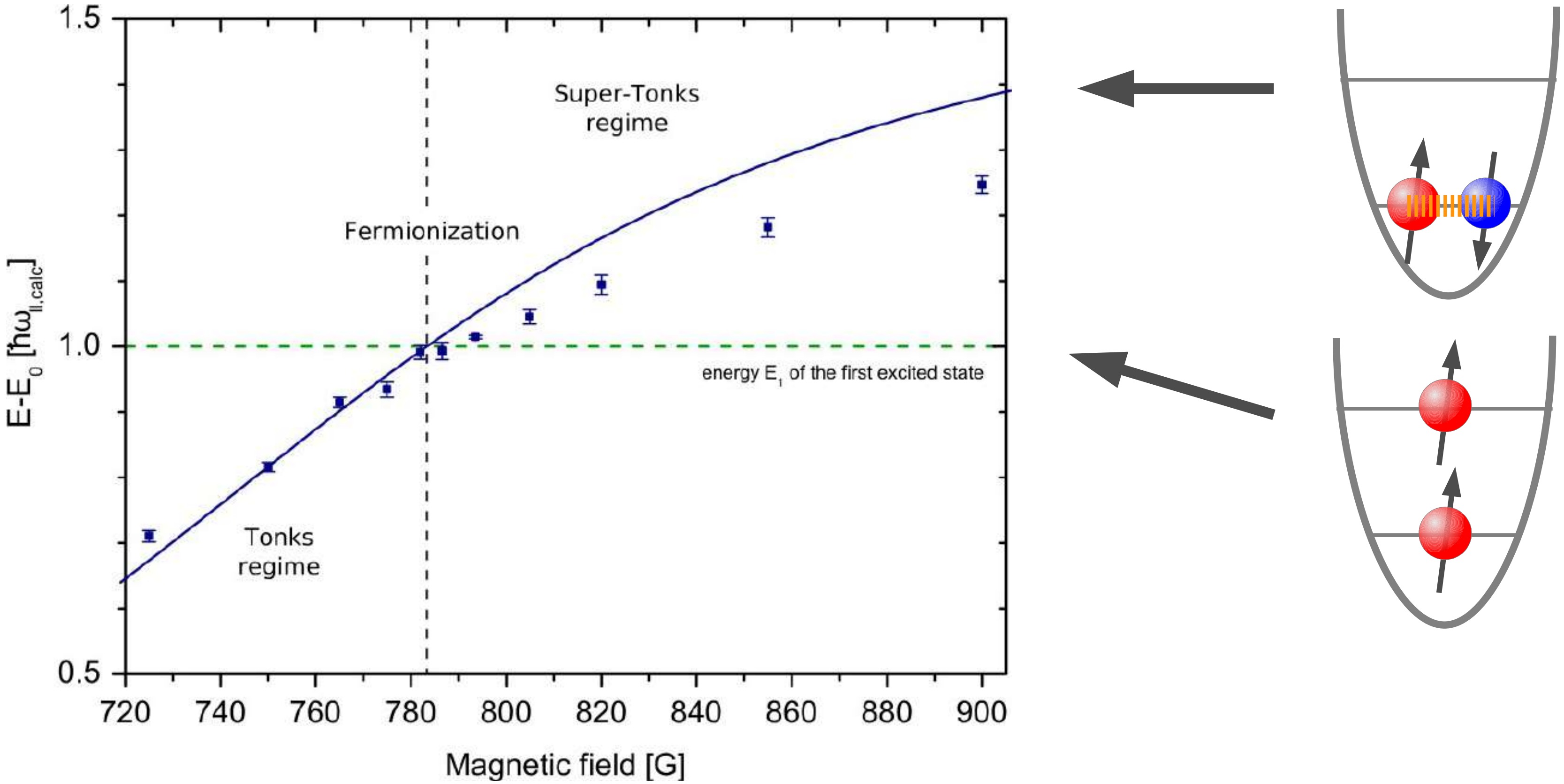
Two distinguishable fermions



Two distinguishable fermions



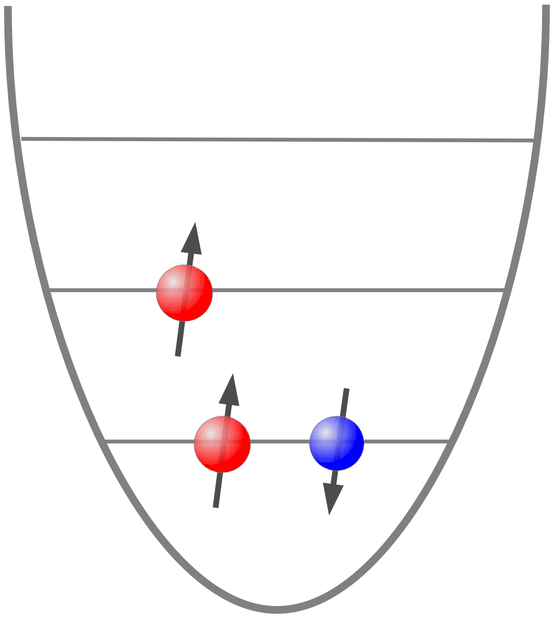
Energy of states



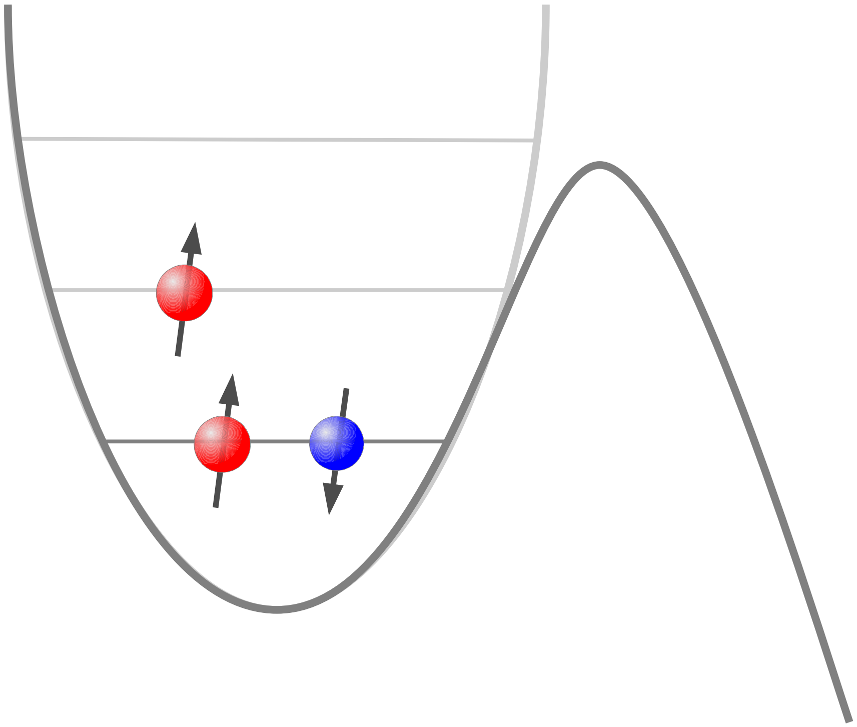
Weak repulsion

Strong repulsion

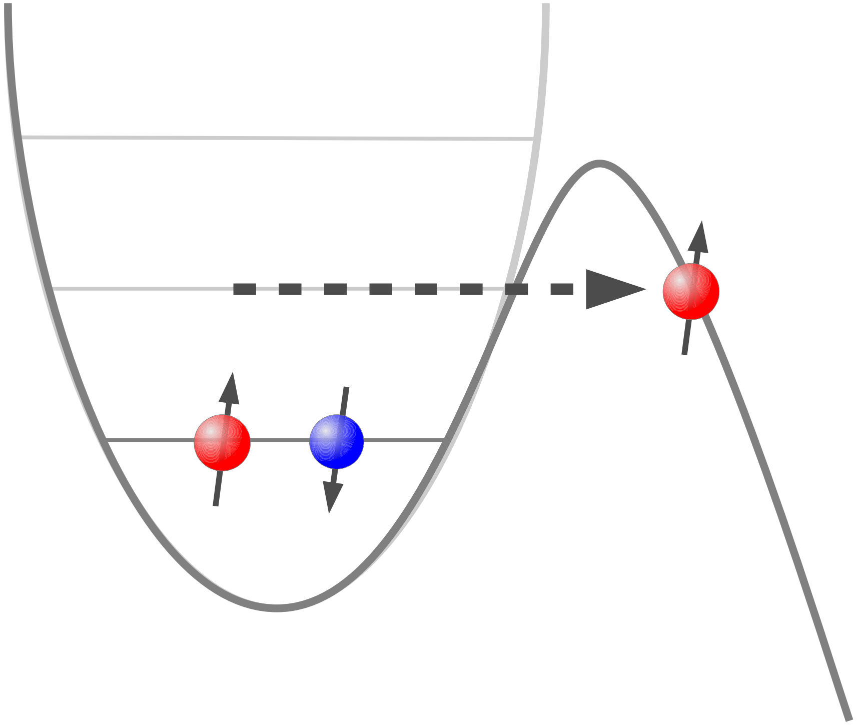
Polaron state



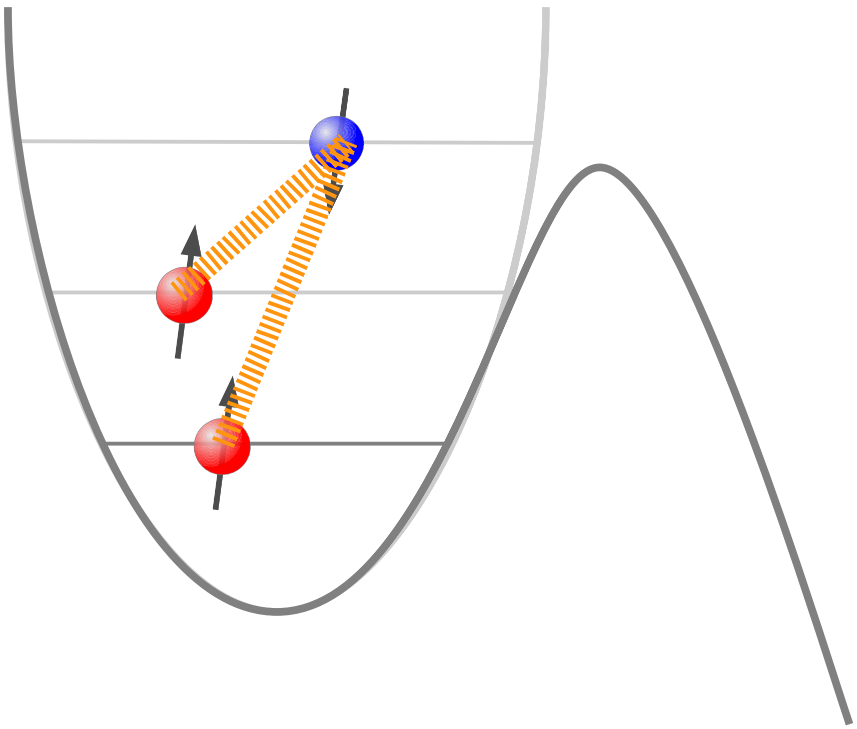
Polaron state



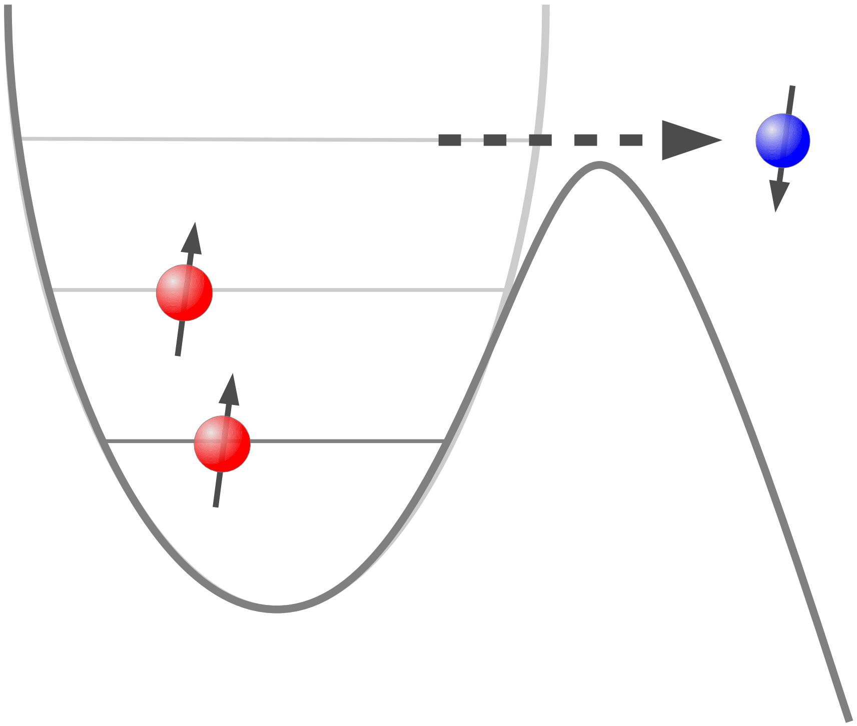
Polaron state



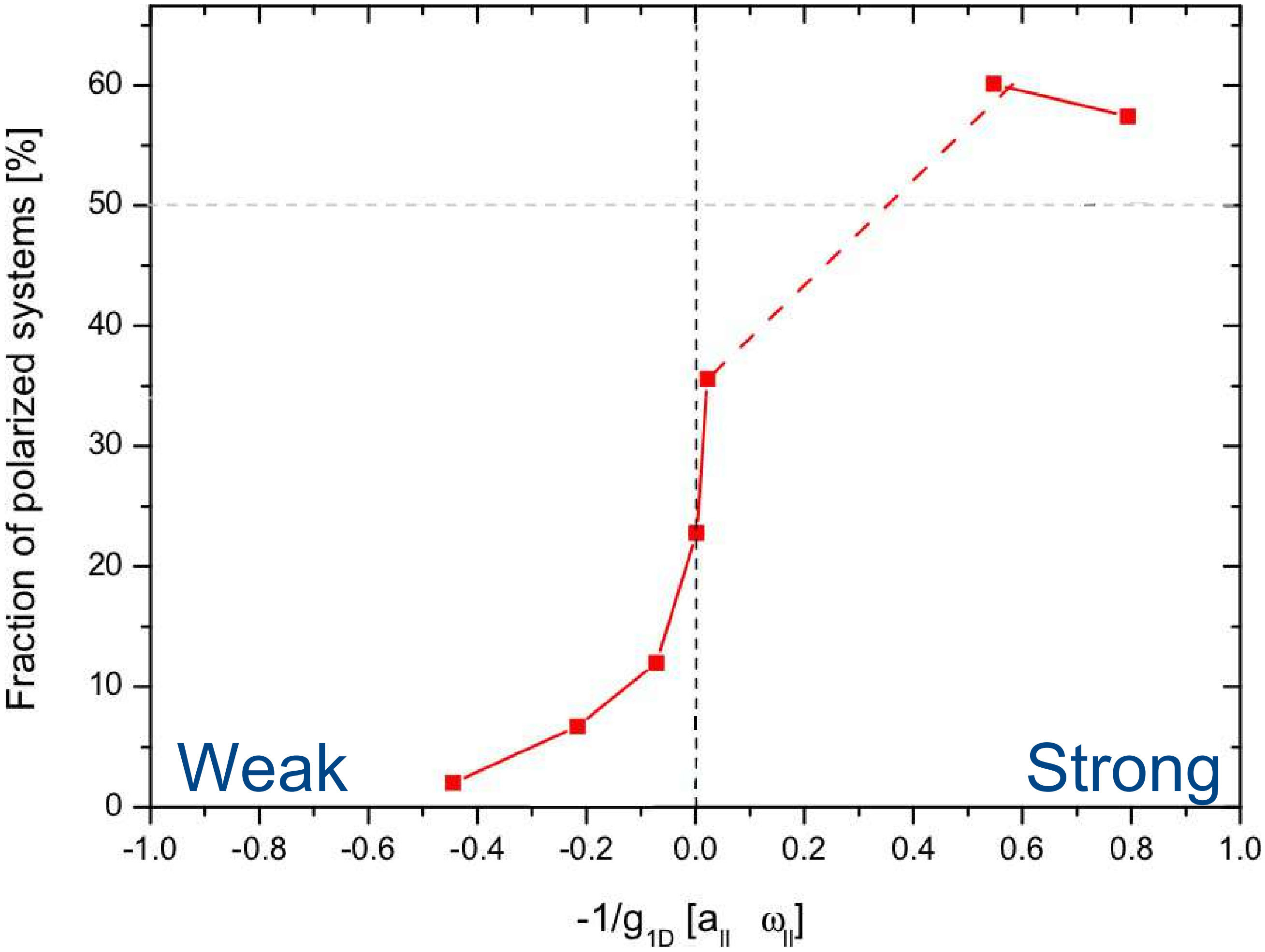
Polaron state

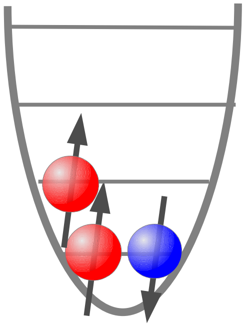


Polaron state

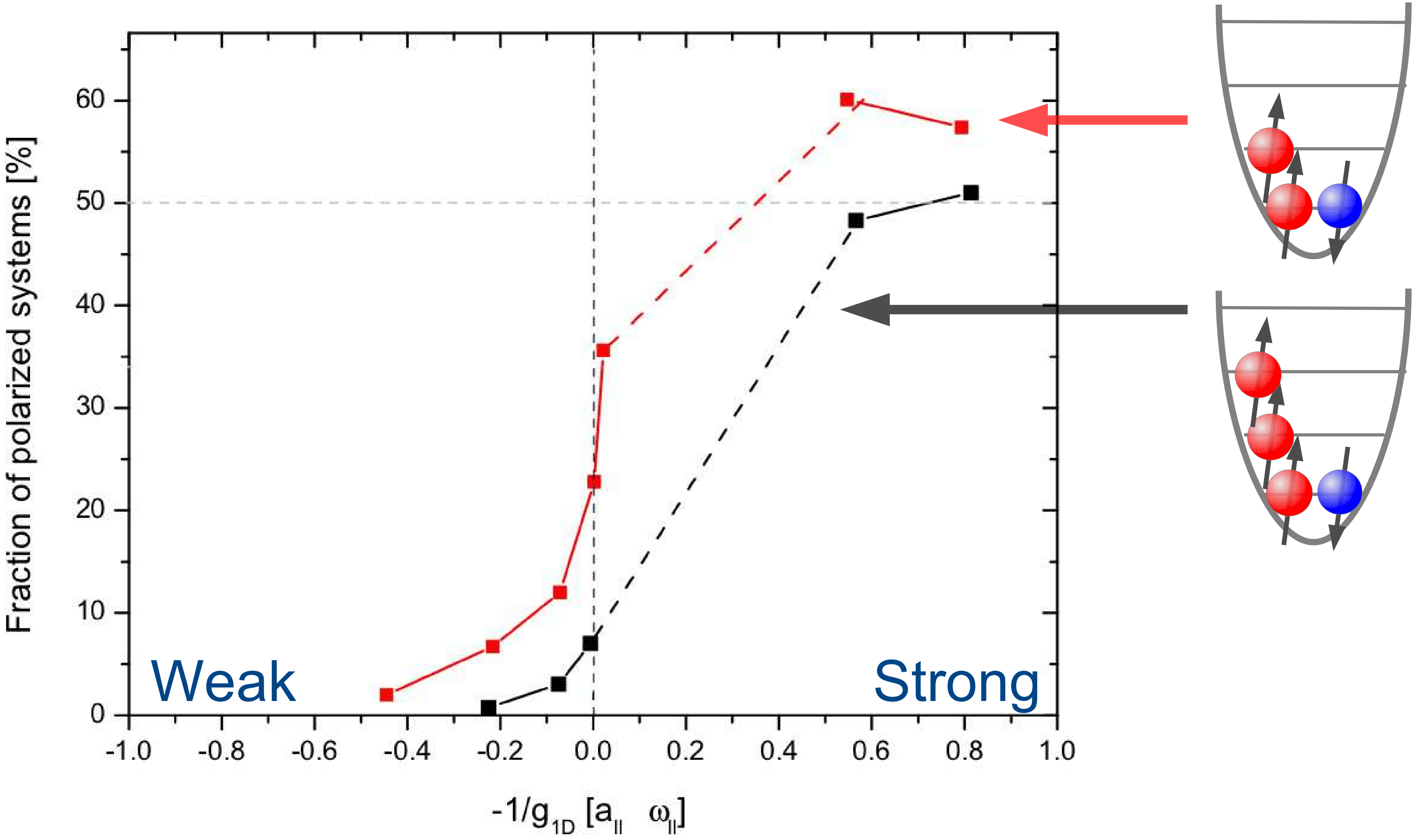


Tunneling probability

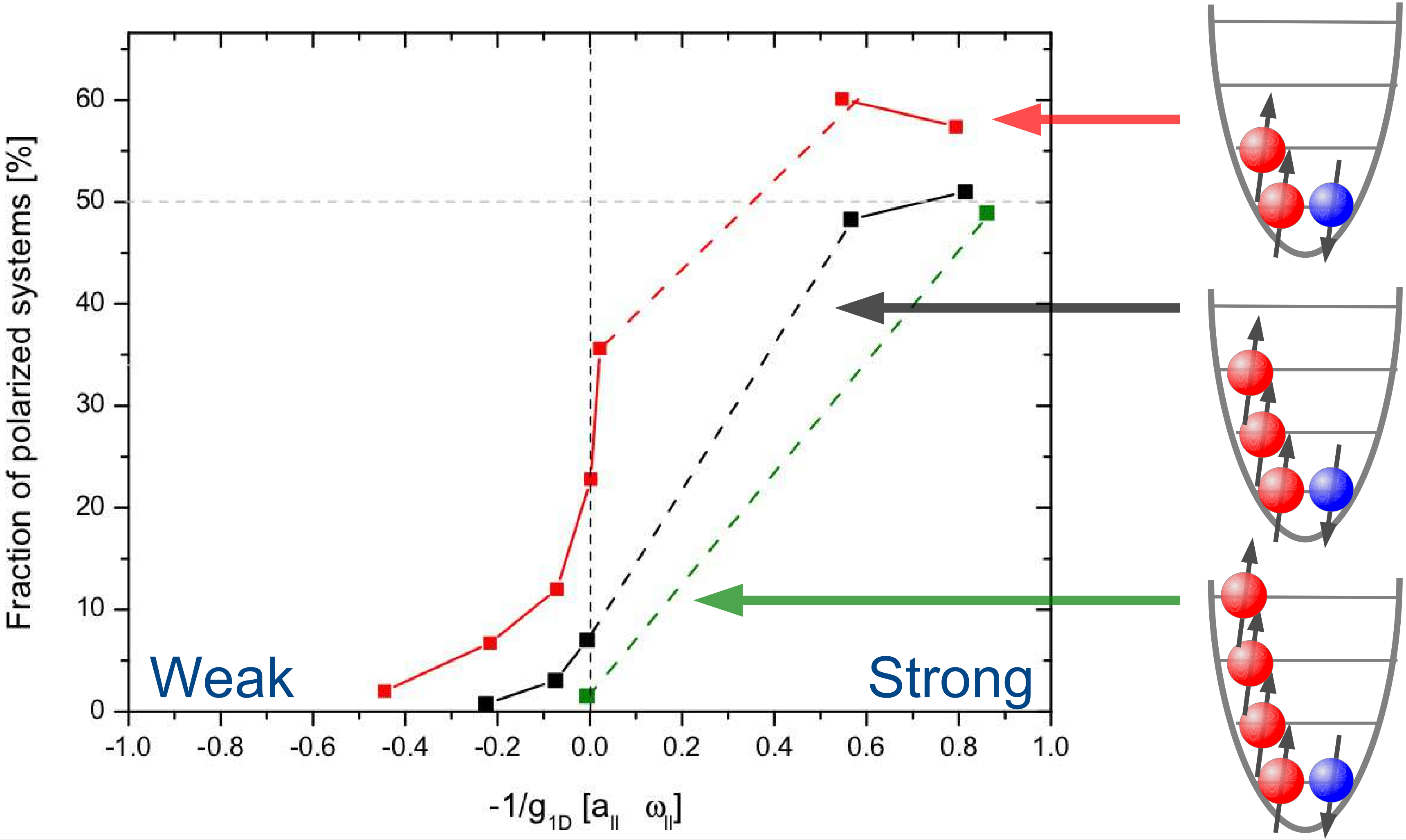




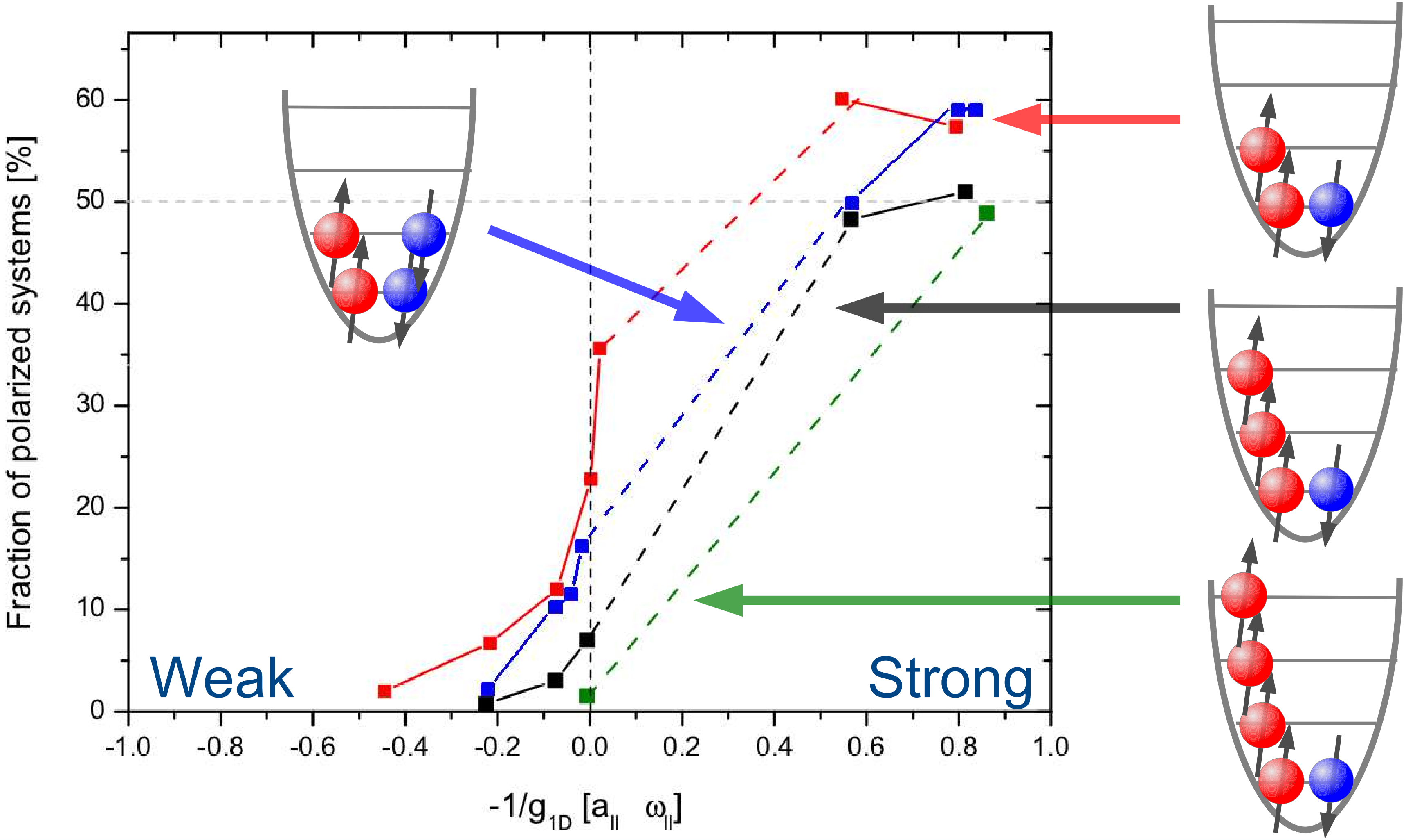
Tunneling probability



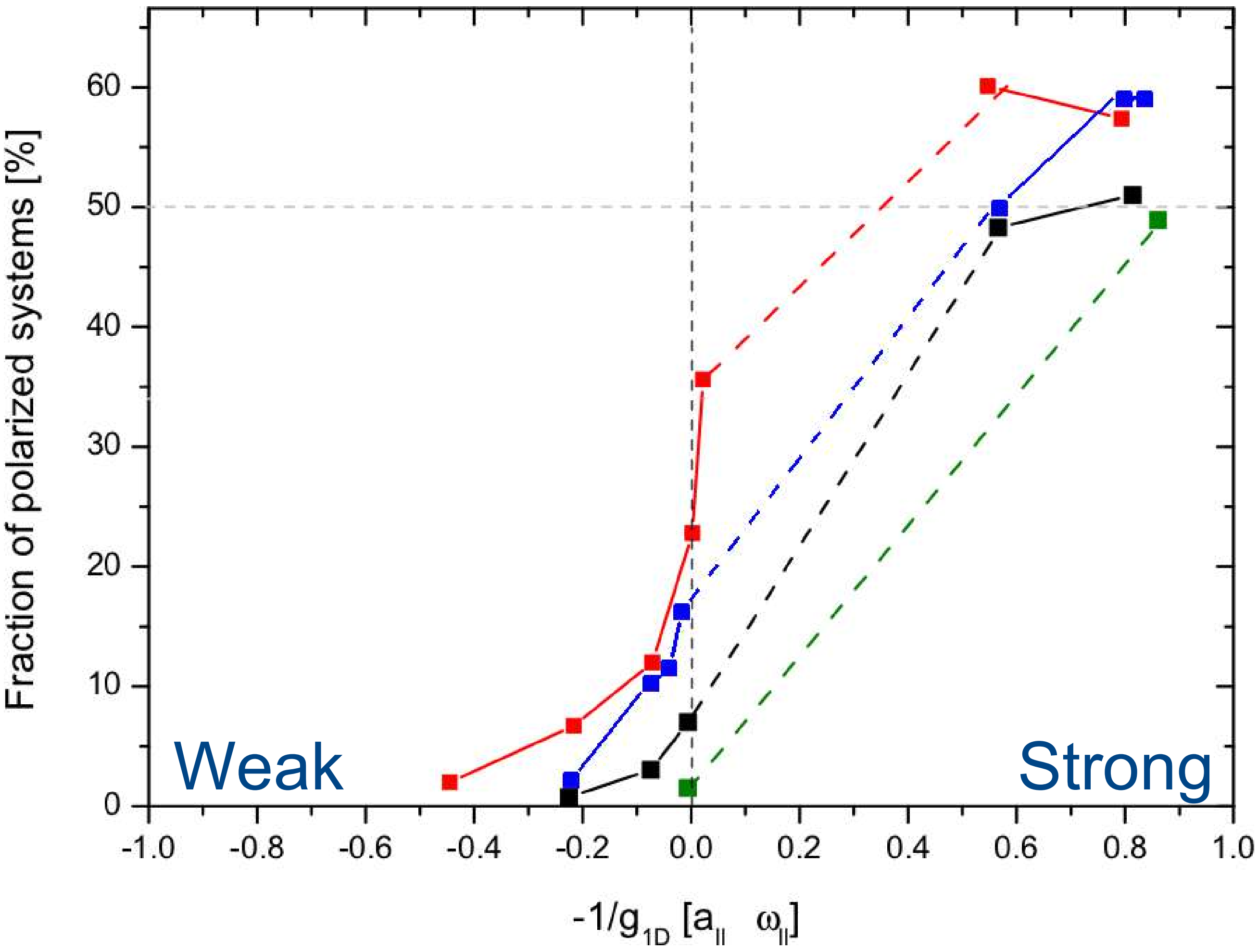
Tunneling probability



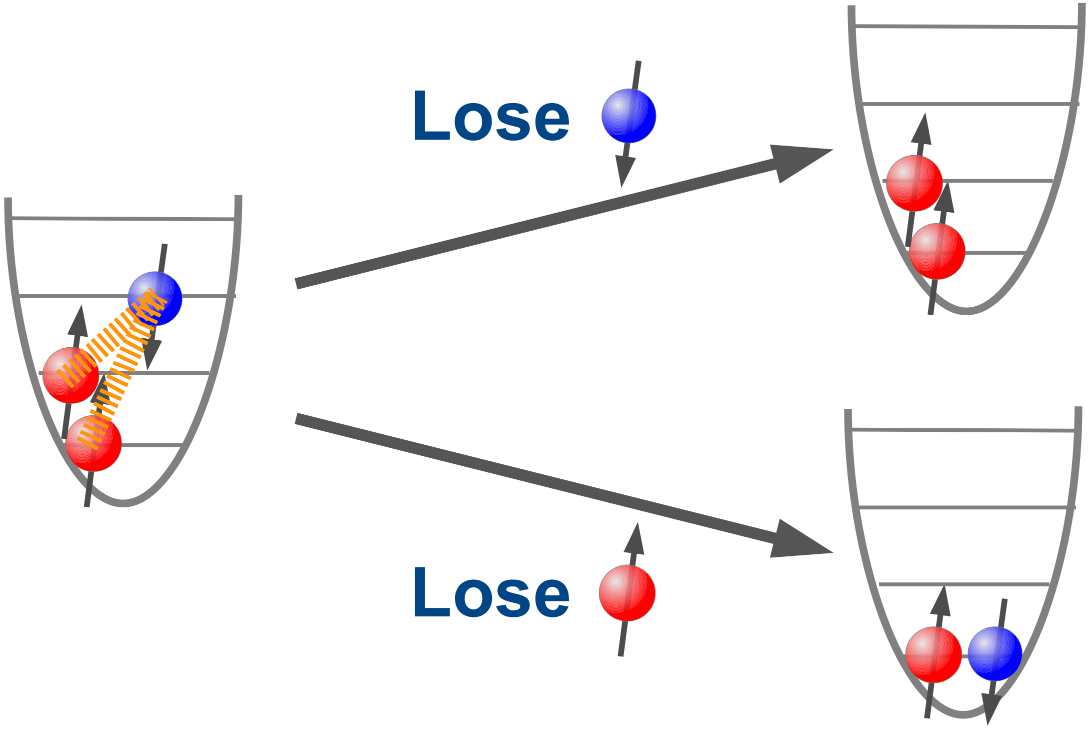
Tunneling probability



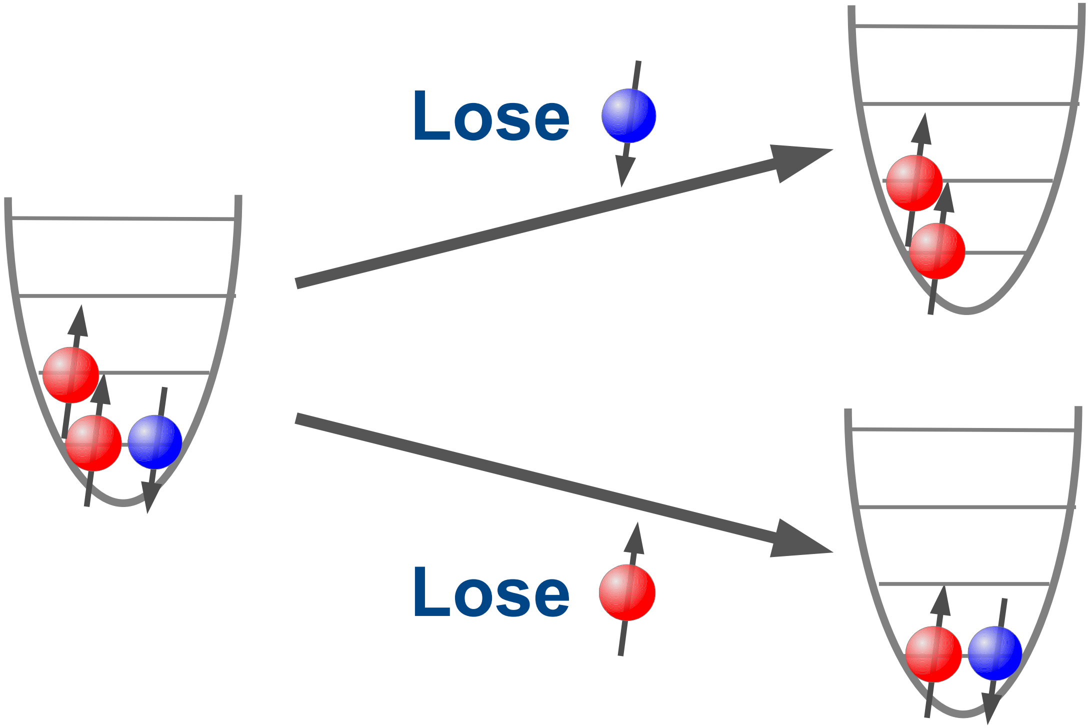
Tunneling probability



Why probability of ½?



Why probability of ½?



Lose

Lose

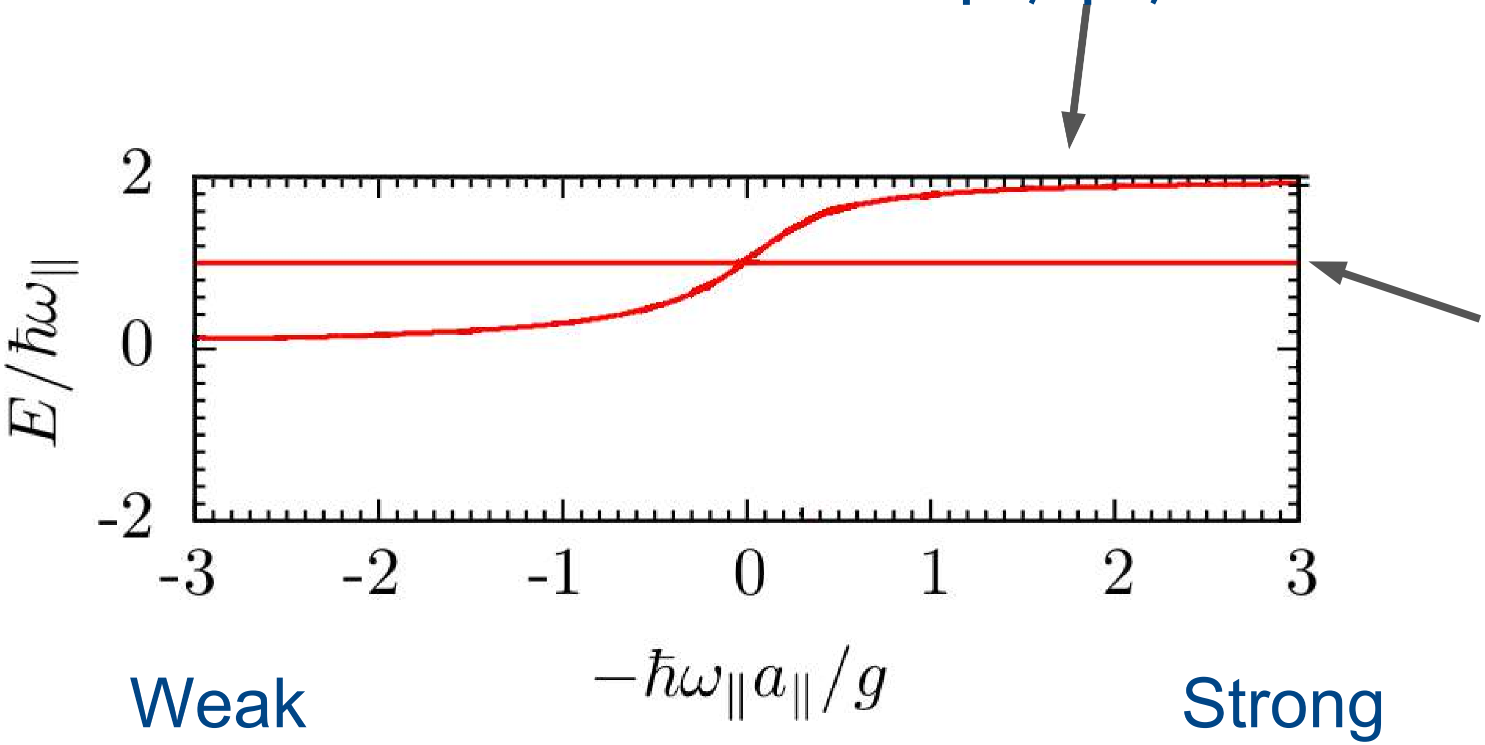
$|\uparrow\uparrow\rangle$ **Ferro**

$|\uparrow\downarrow\rangle + |\downarrow\uparrow\rangle$ **Ferro**

$|\uparrow\downarrow\rangle - |\downarrow\uparrow\rangle$ **Para**

Finding the missing probability

$|\uparrow\downarrow\rangle - |\downarrow\uparrow\rangle$



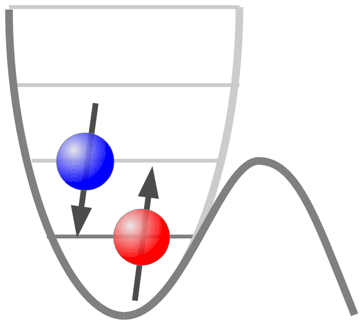
$|\uparrow\uparrow\rangle$ **or**

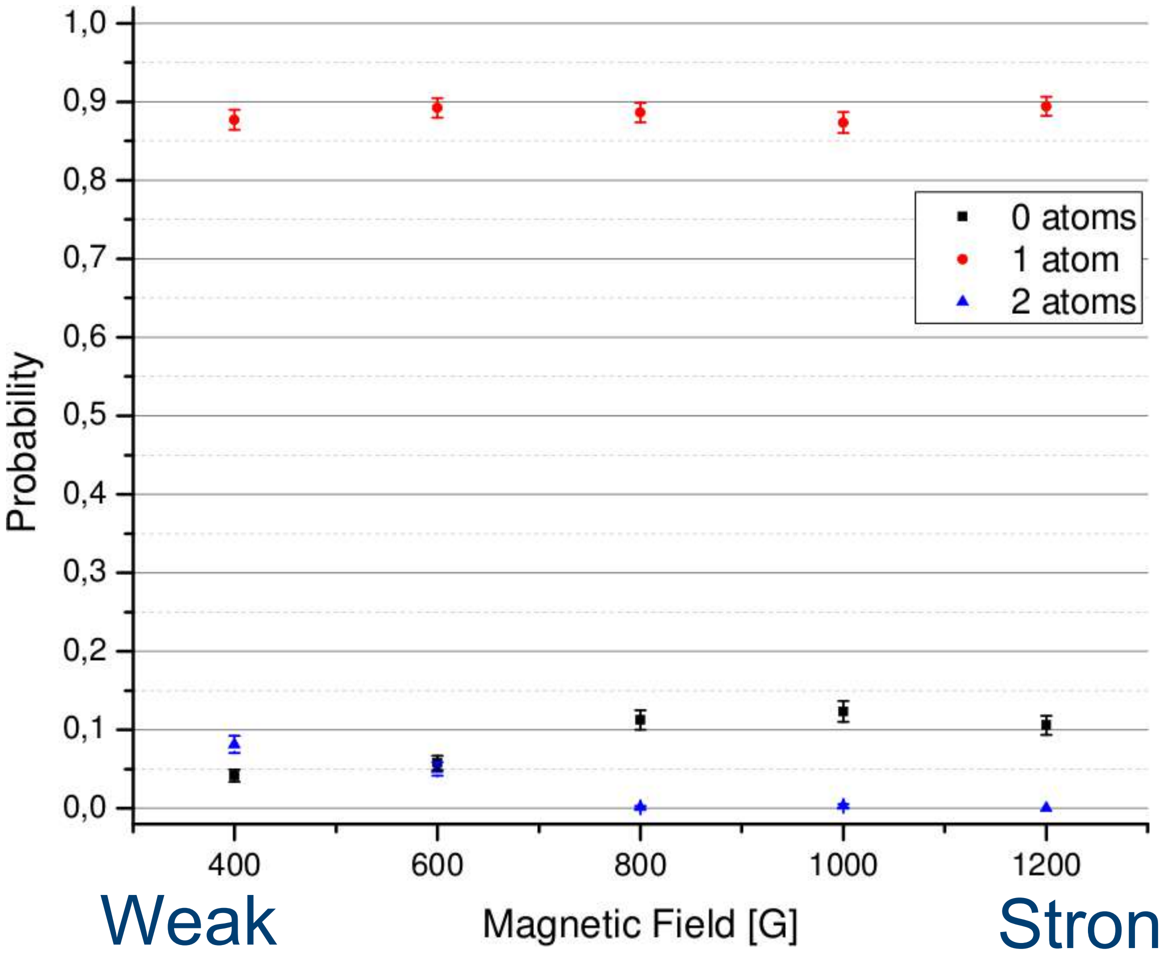
$|\uparrow\downarrow\rangle + |\downarrow\uparrow\rangle$

Weak

Strong

Tunneling probability

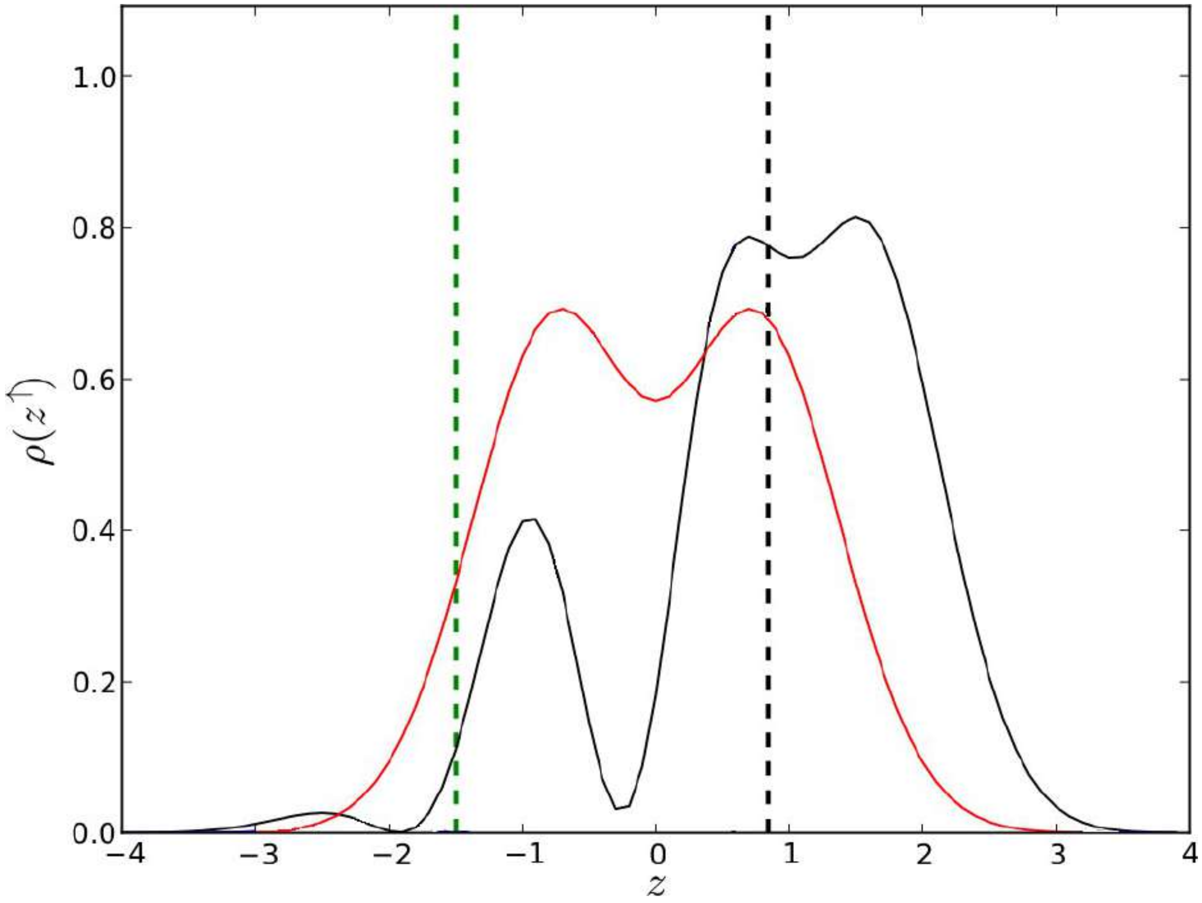




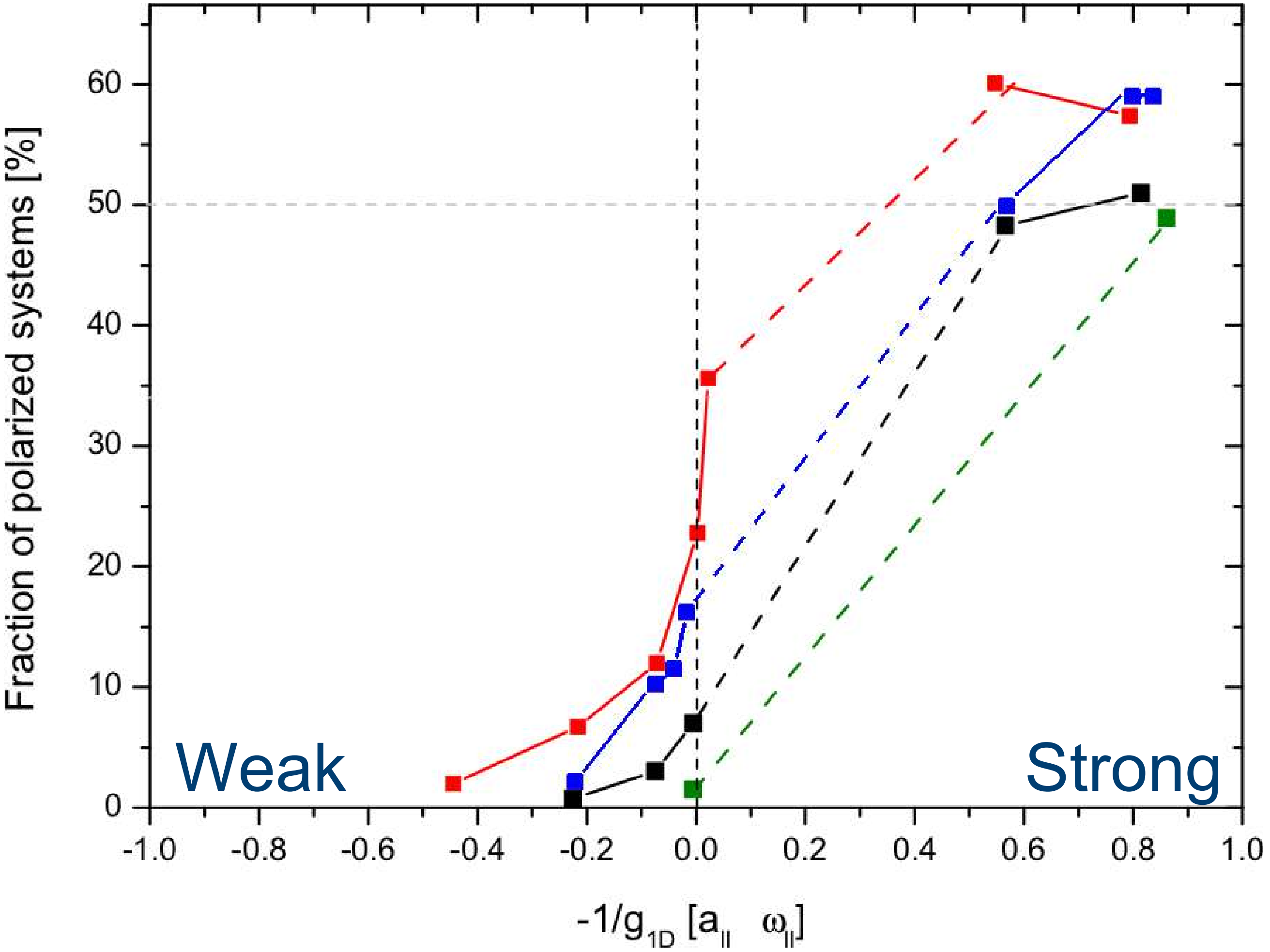
Weak

Strong

Density profiles

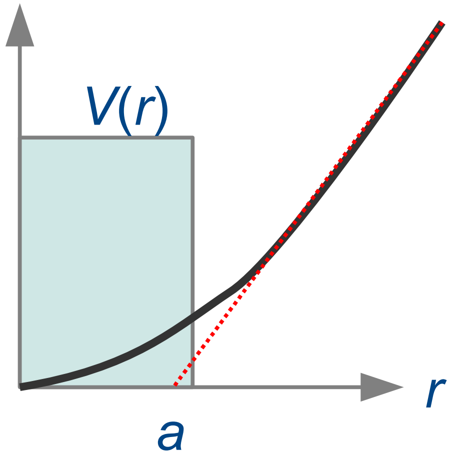


Losses


Fraction of polarized systems [%]
0
10
20
30
40
50
60
-1.0
-0.8
-0.6
-0.4
-0.2
0.0
0.2
0.4
0.6
0.8
1.0
-1/g1D [a|| ω||]
Weak
Strong

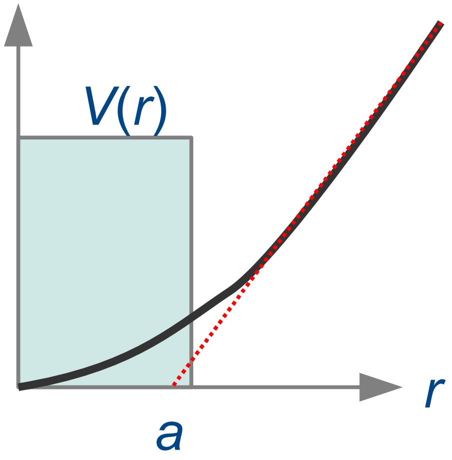
Two-atom scattering

Repulsive

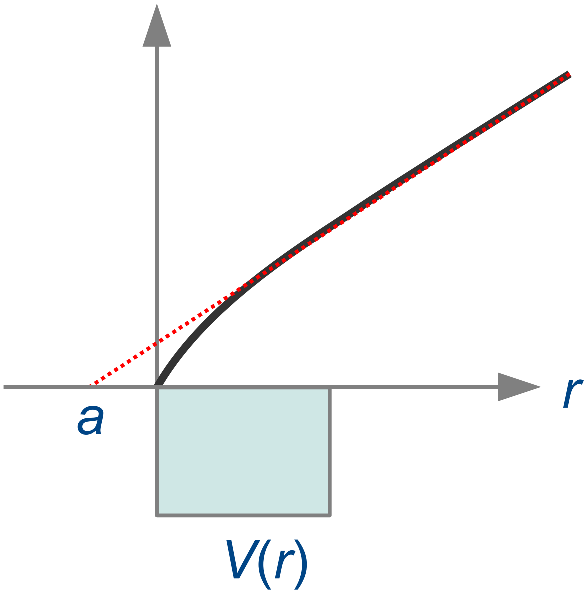


Two-atom scattering

Repulsive

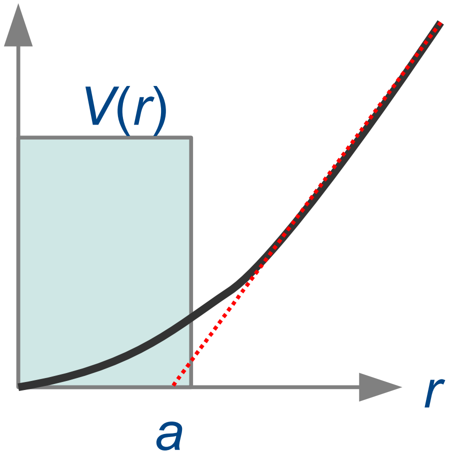


Attractive

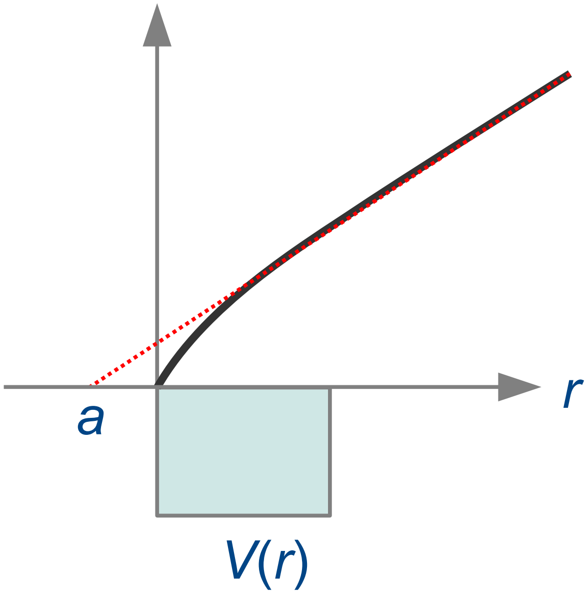


Two-atom scattering

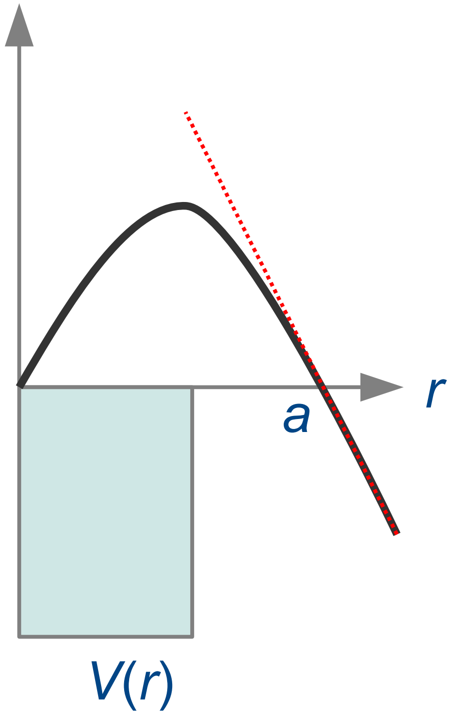
Repulsive



Attractive

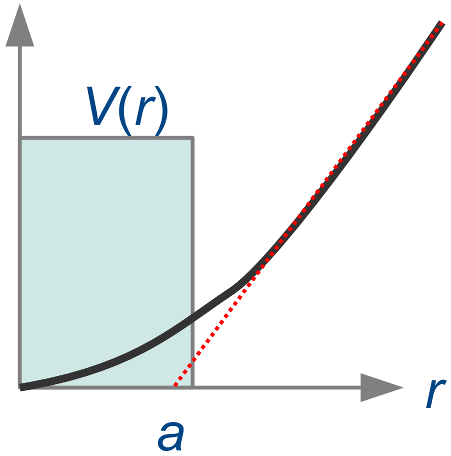


Repulsive

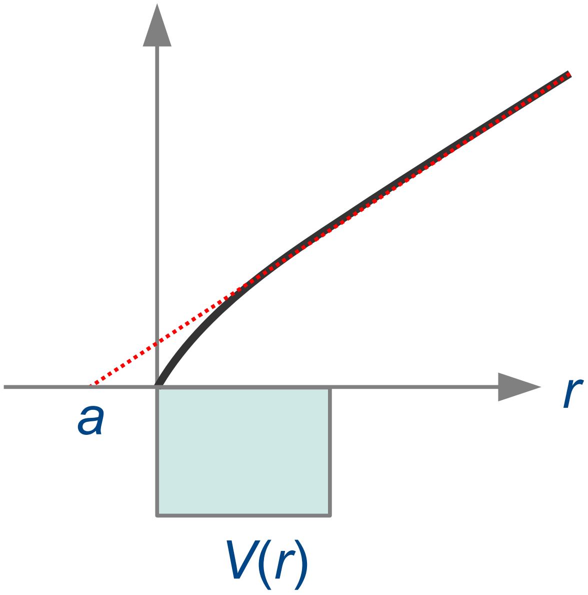


Two-atom scattering

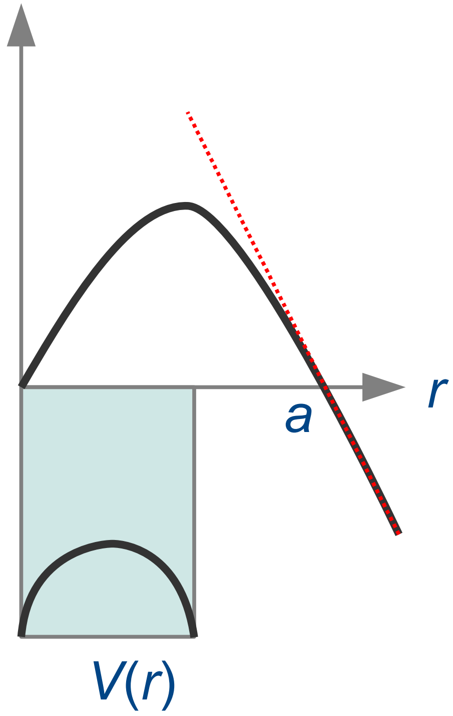
Repulsive



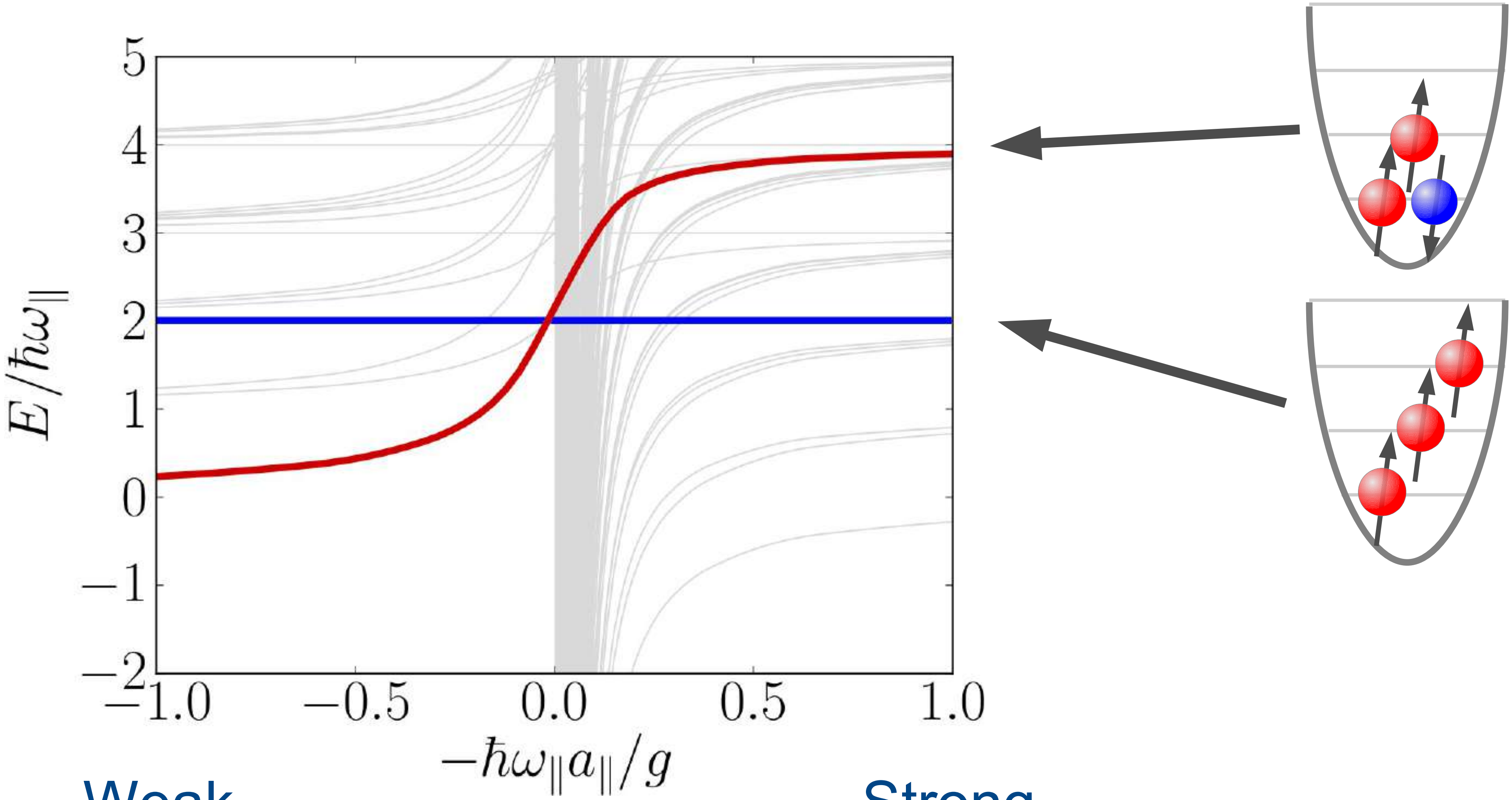
Attractive



Repulsive



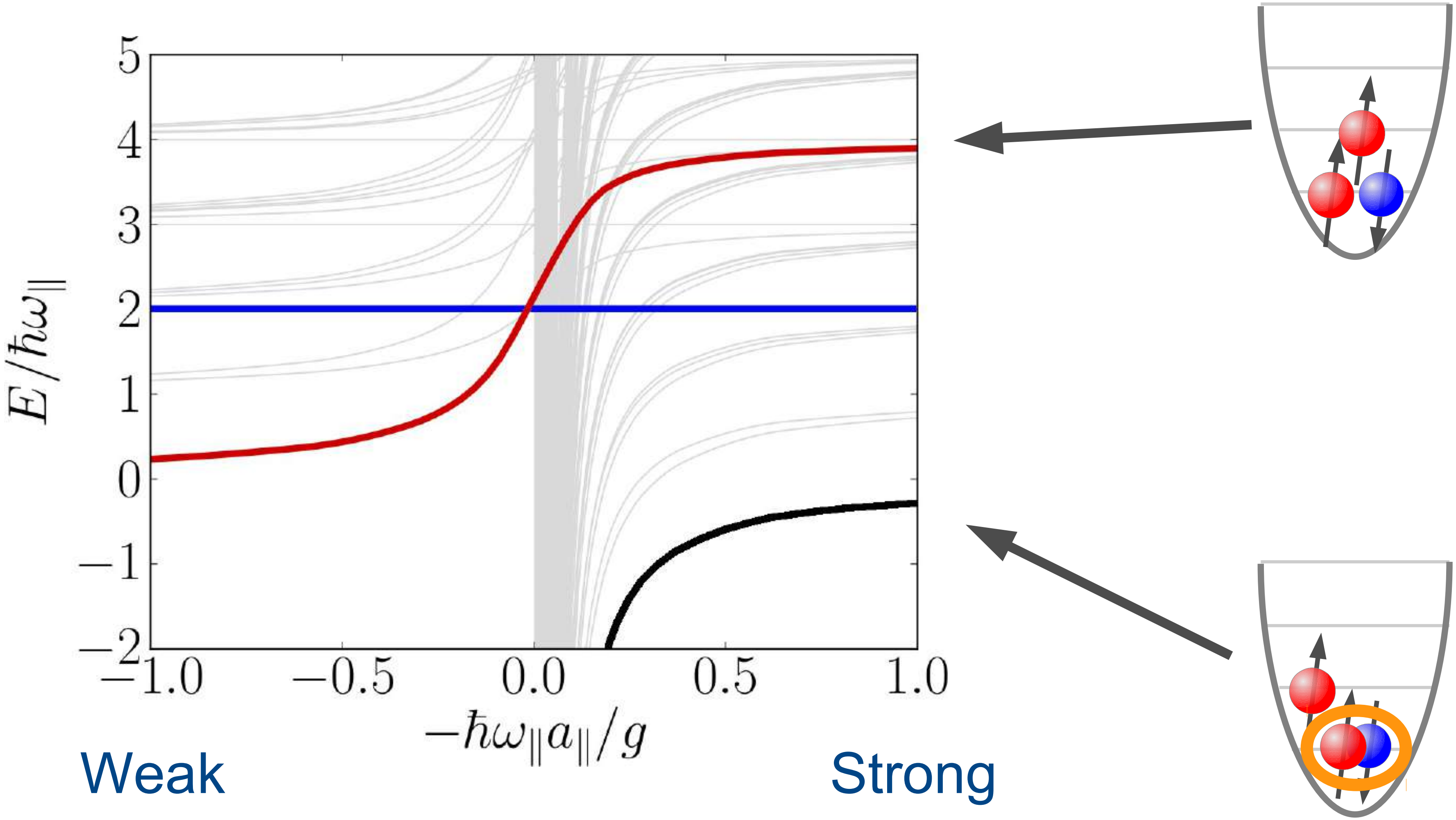
Three-atom bound state



Weak

Strong

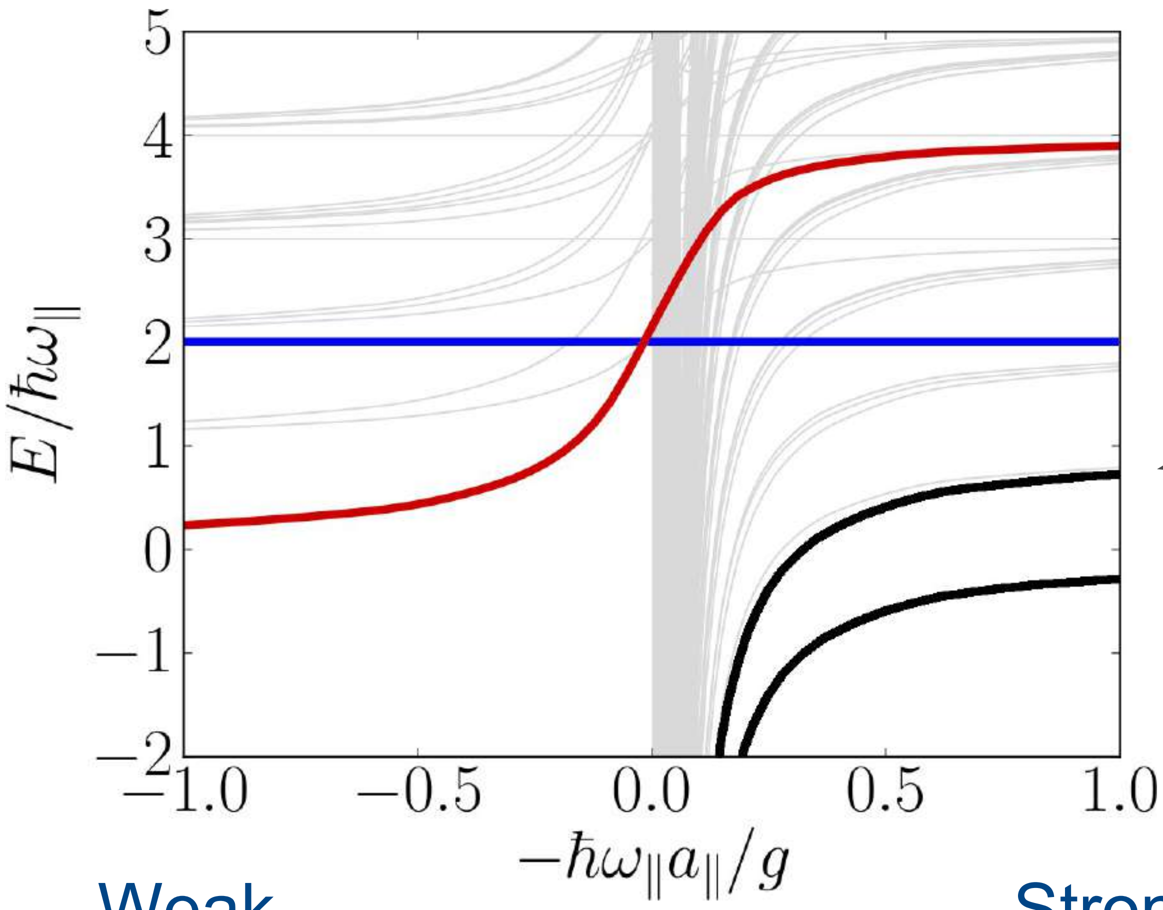
Three-atom bound state

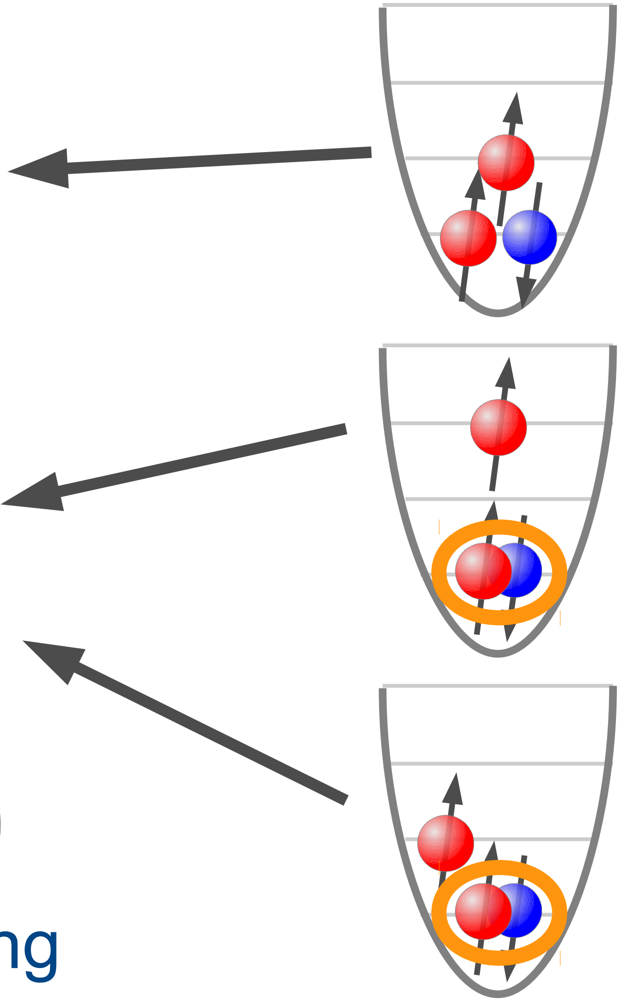


Weak

Strong

Three-atom bound state

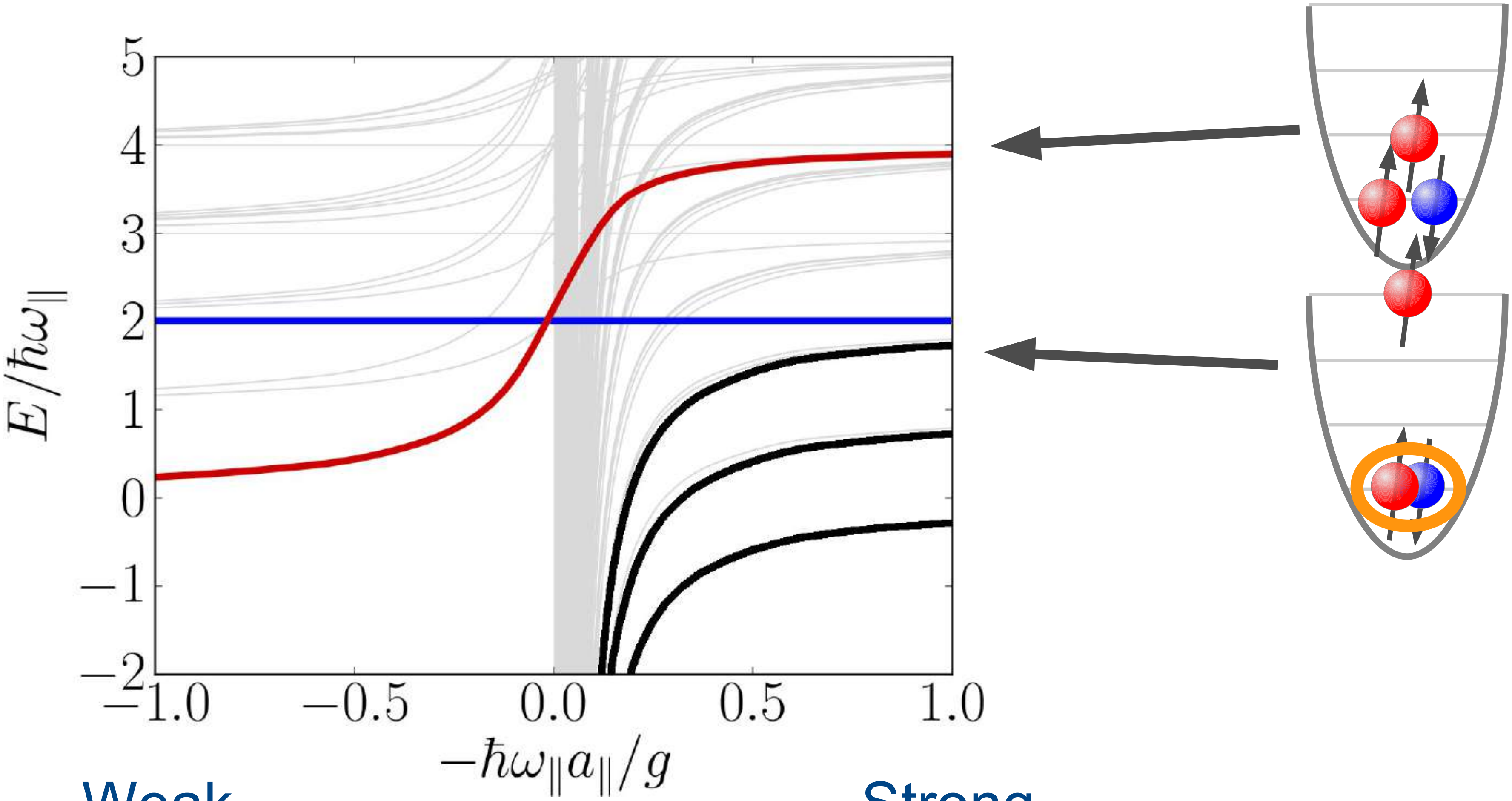




Weak

Strong

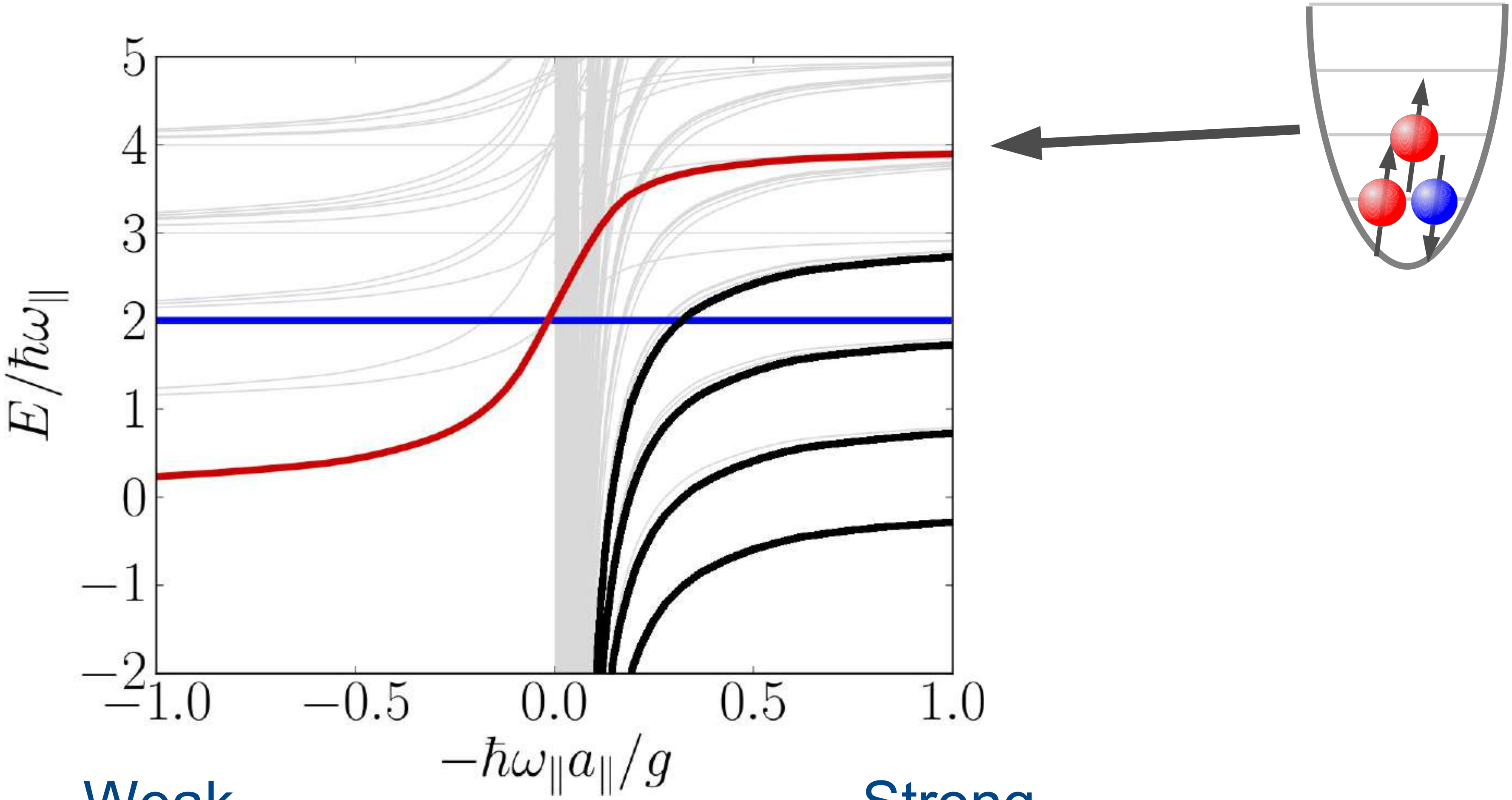
Three-atom bound state



Weak

Strong

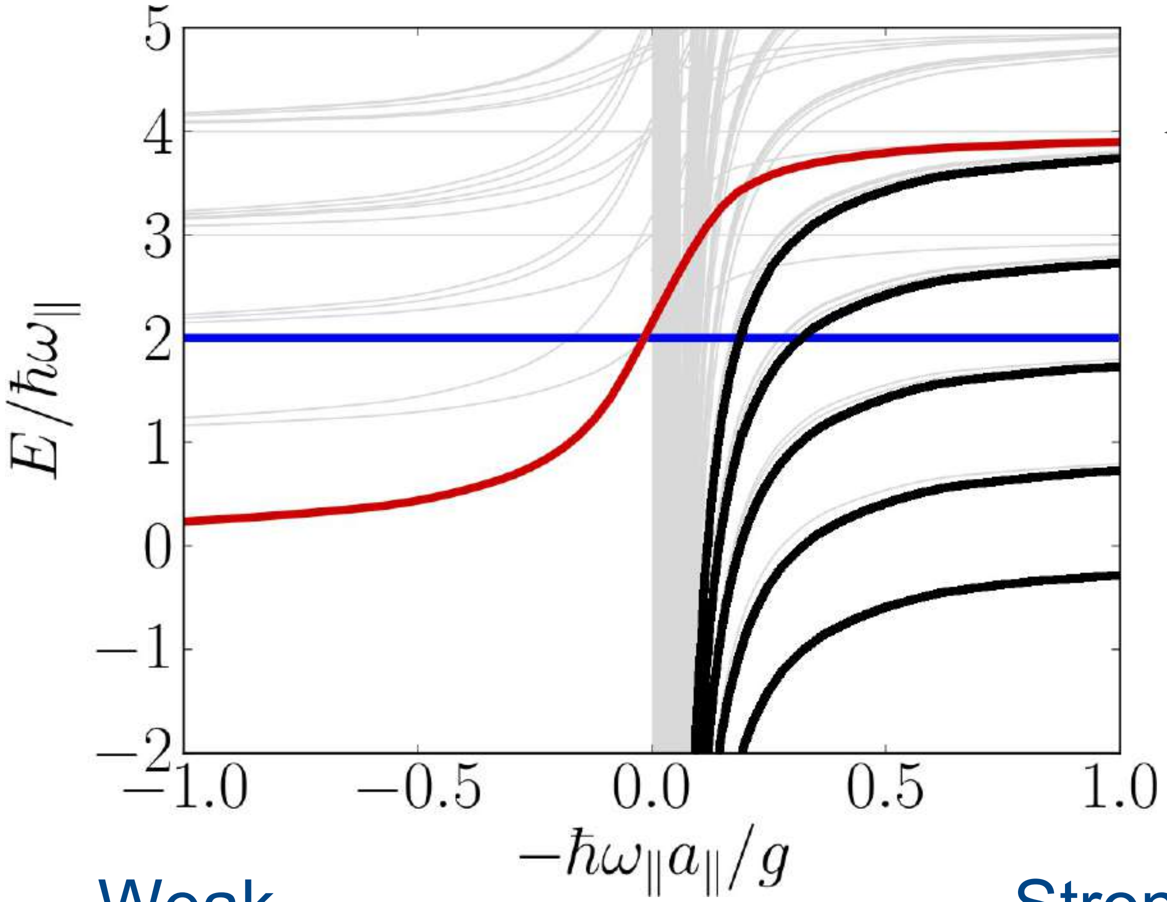
Three-atom bound state

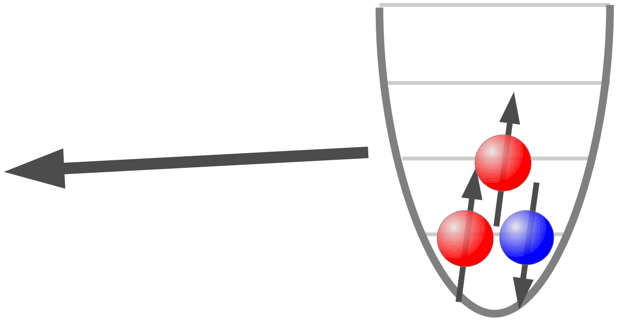


Weak

Strong

Three-atom bound state

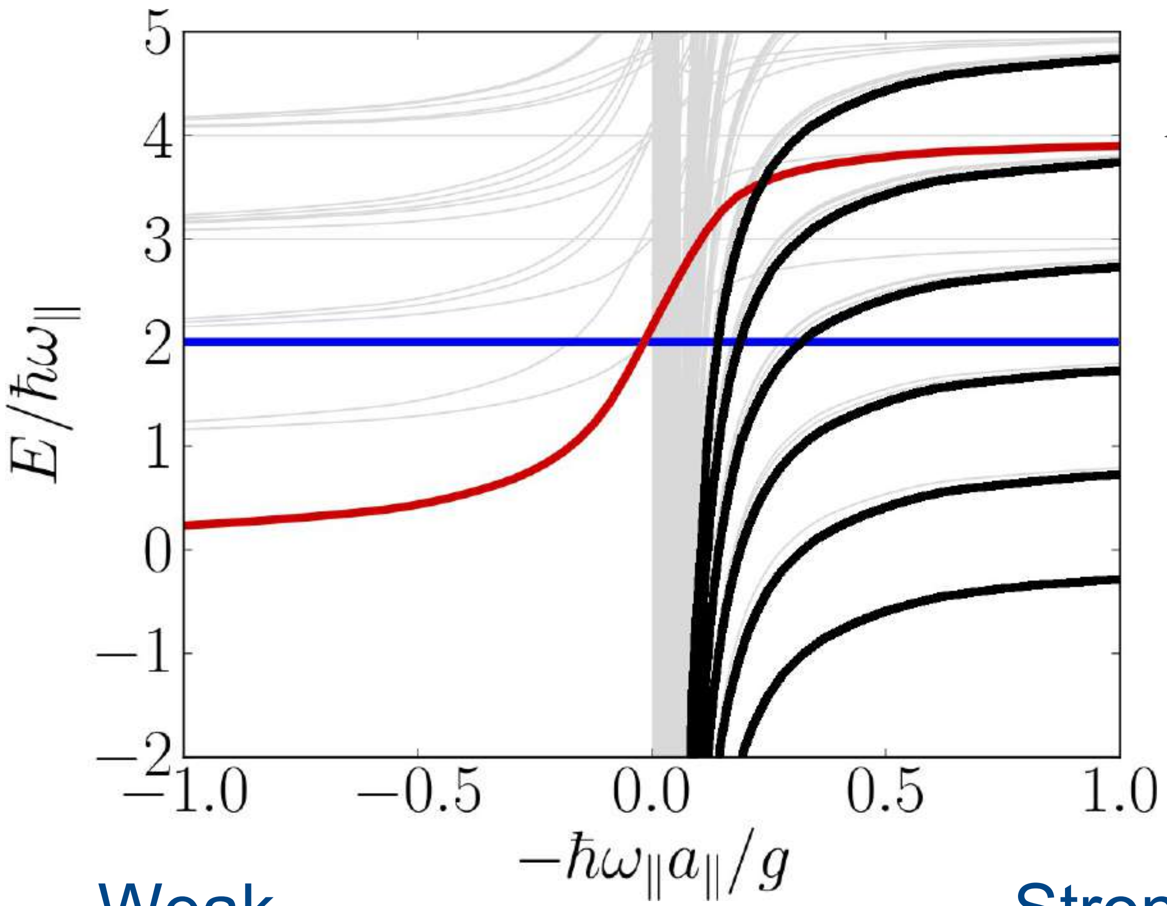


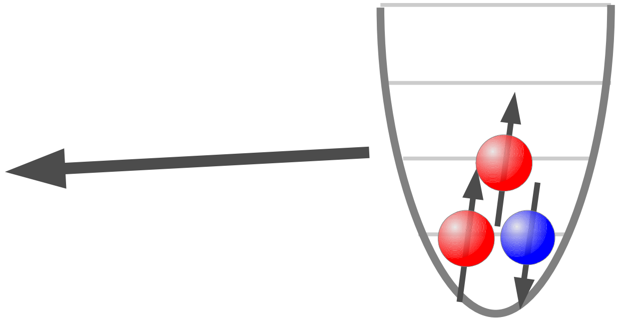


Weak

Strong

Three-atom bound state





Weak

Strong

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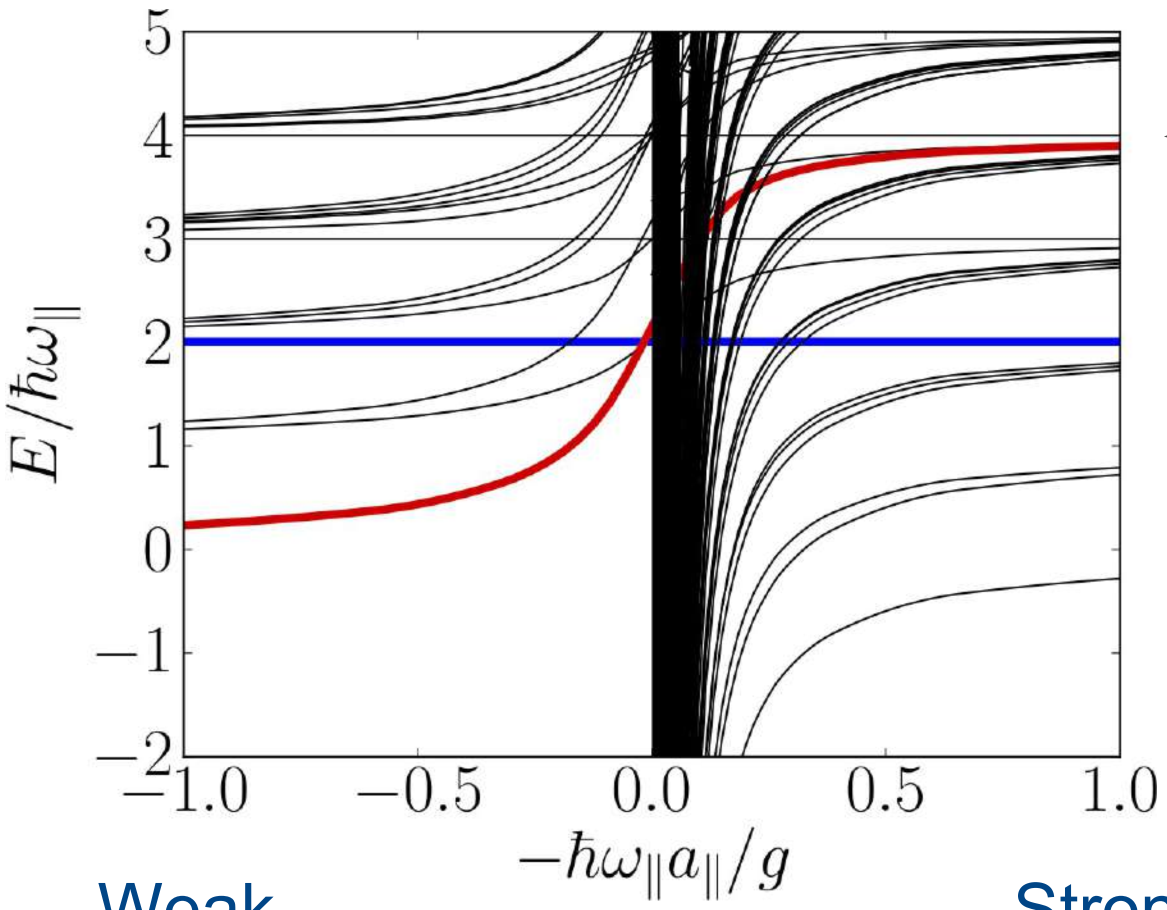
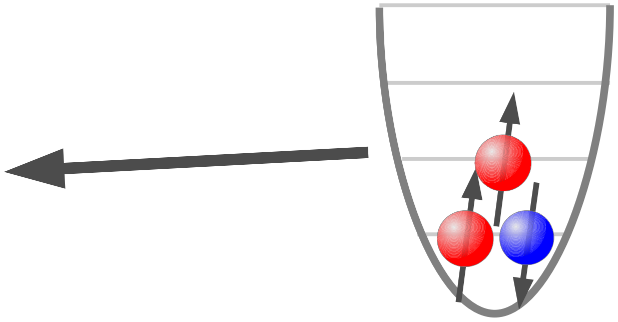
Three-atom bound state

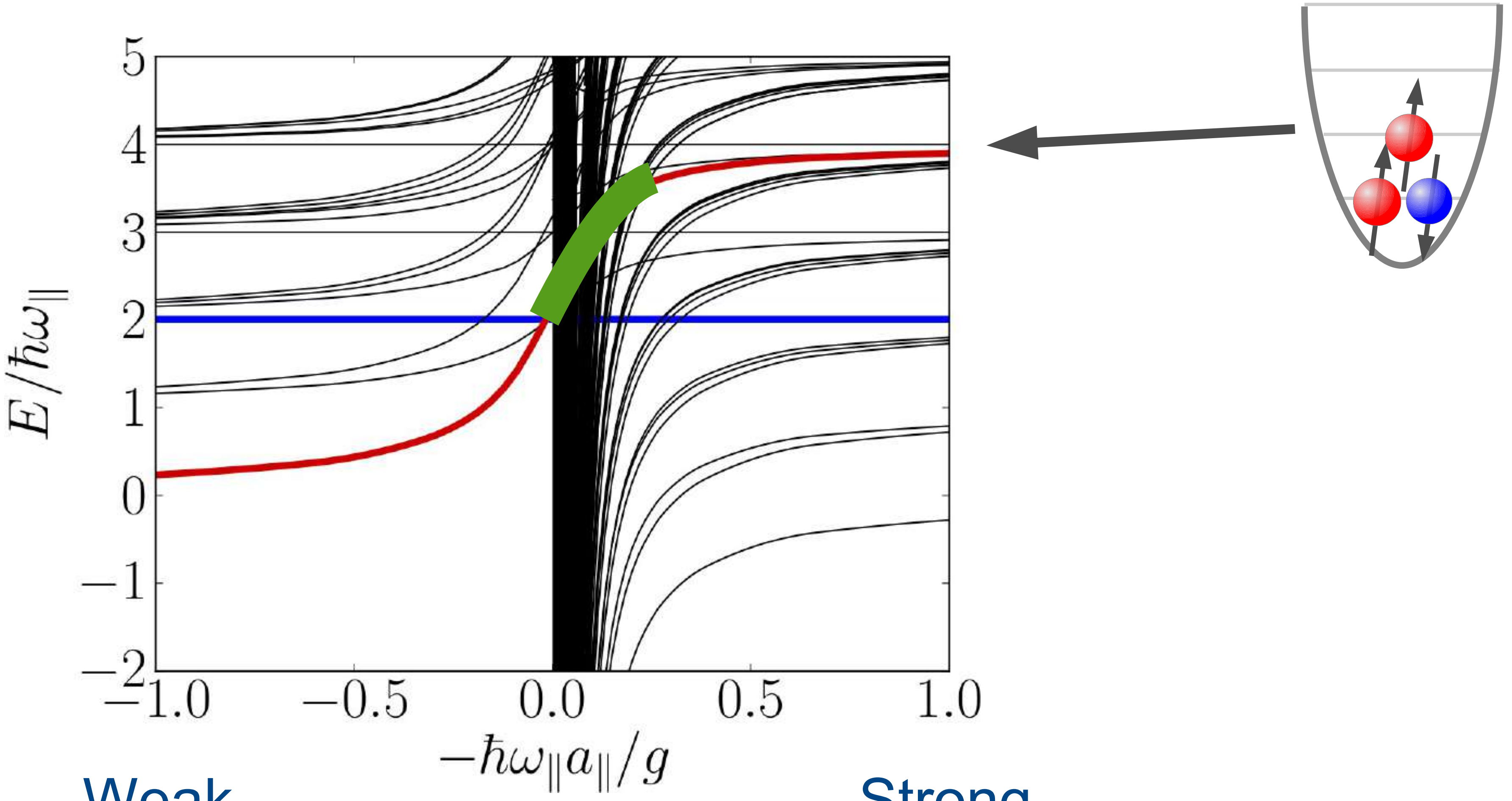




Weak

Strong

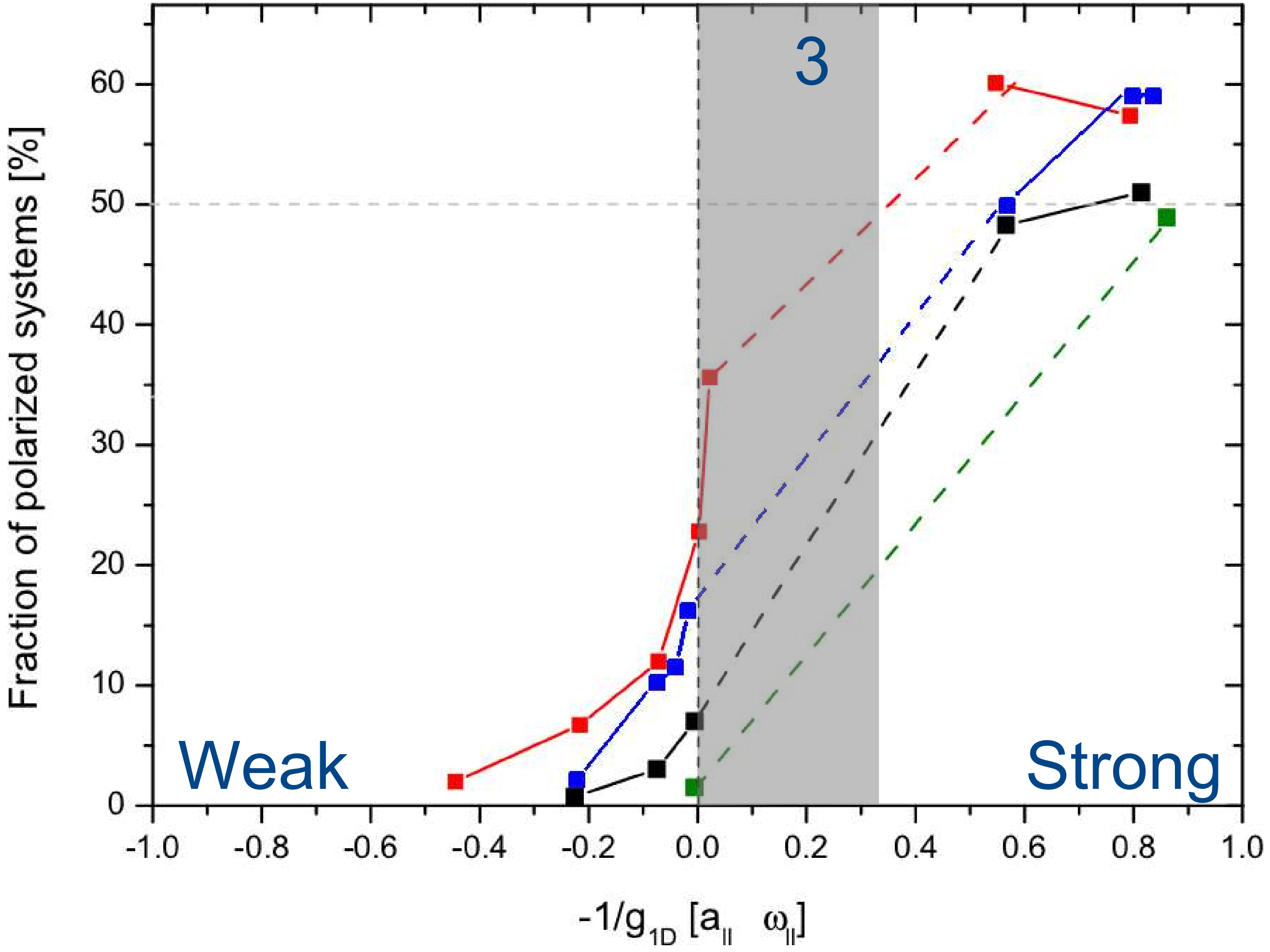
Three-atom bound state



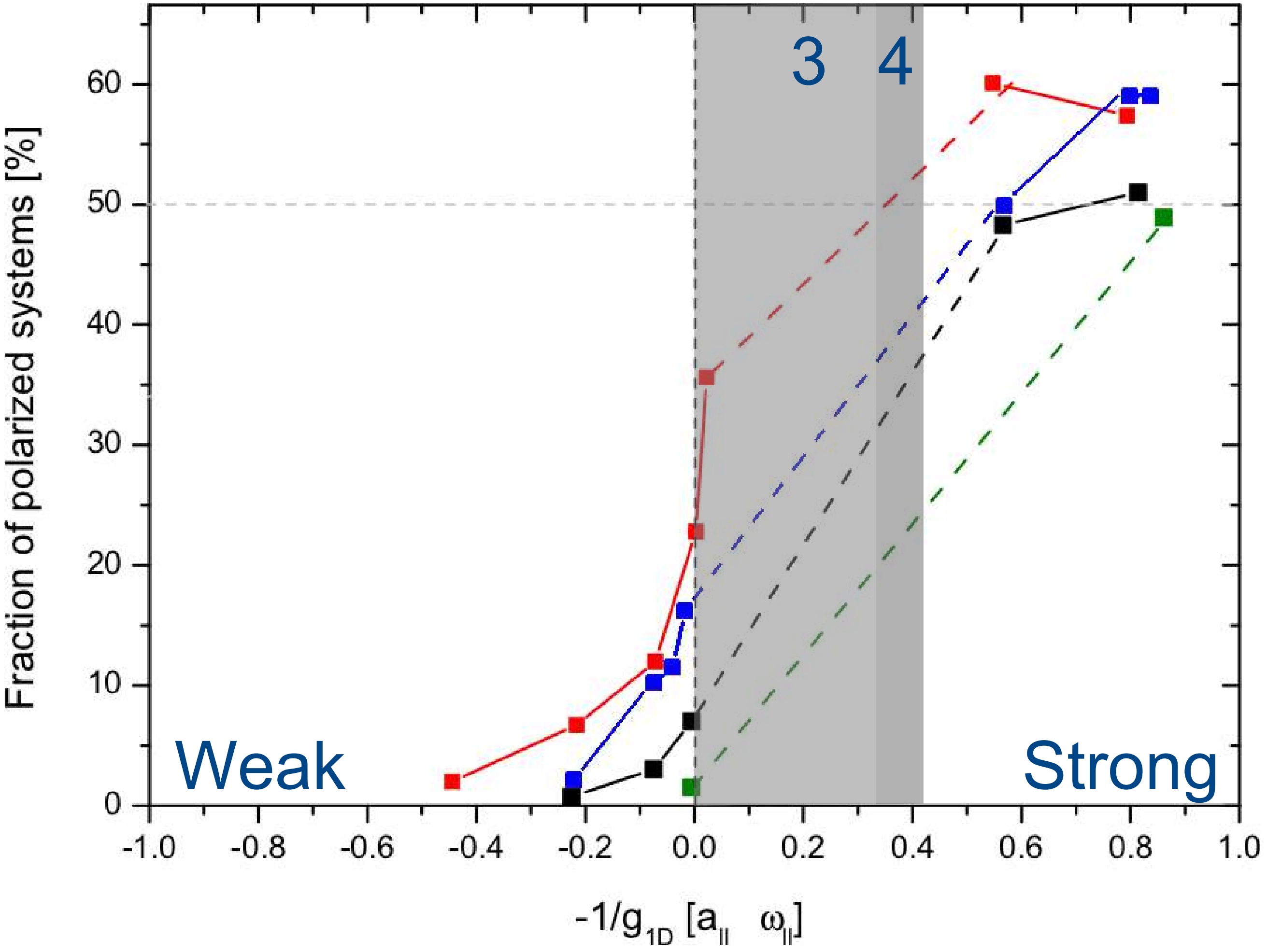
Weak

Strong

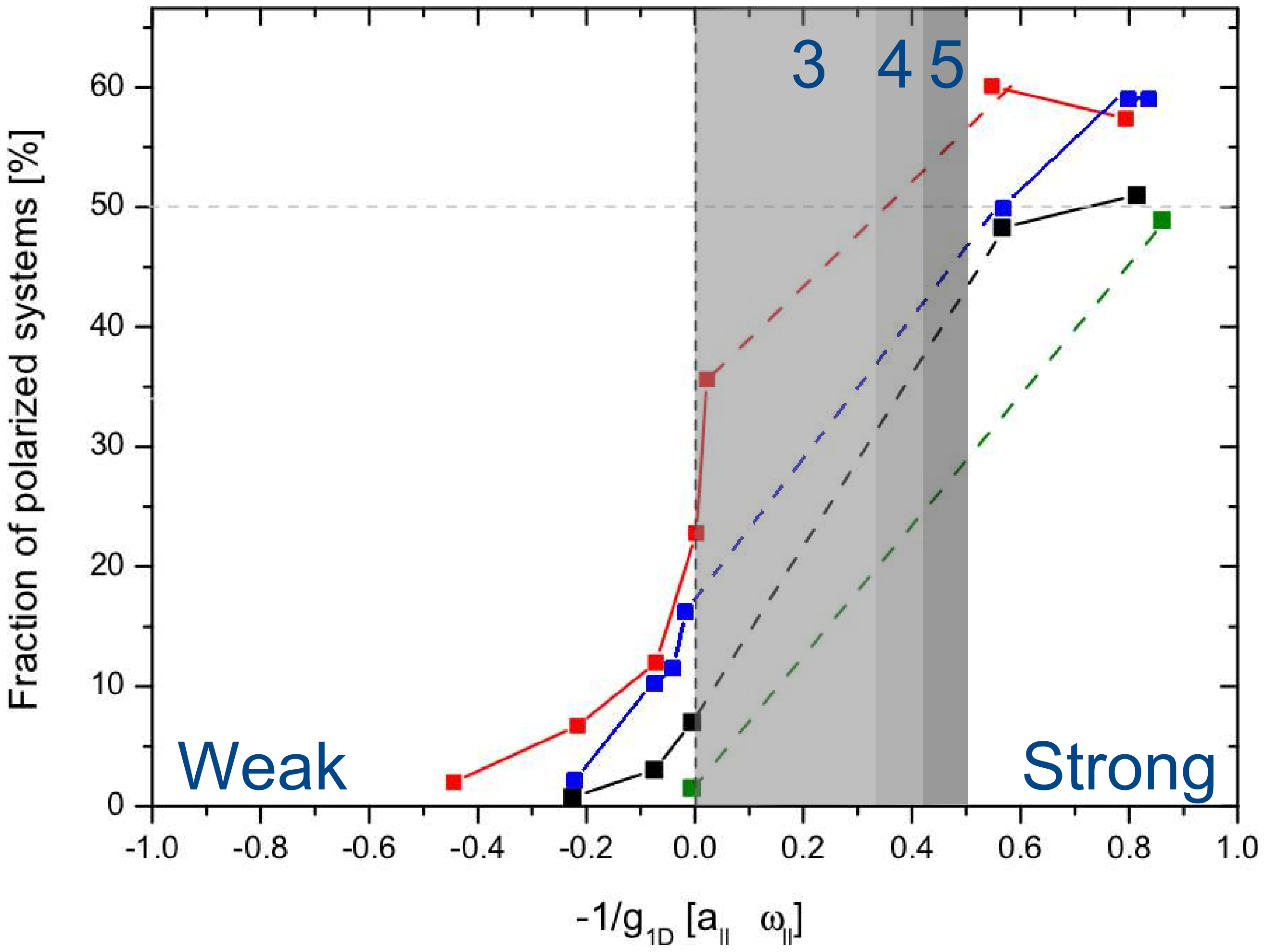
Loss affected region



Loss affected region

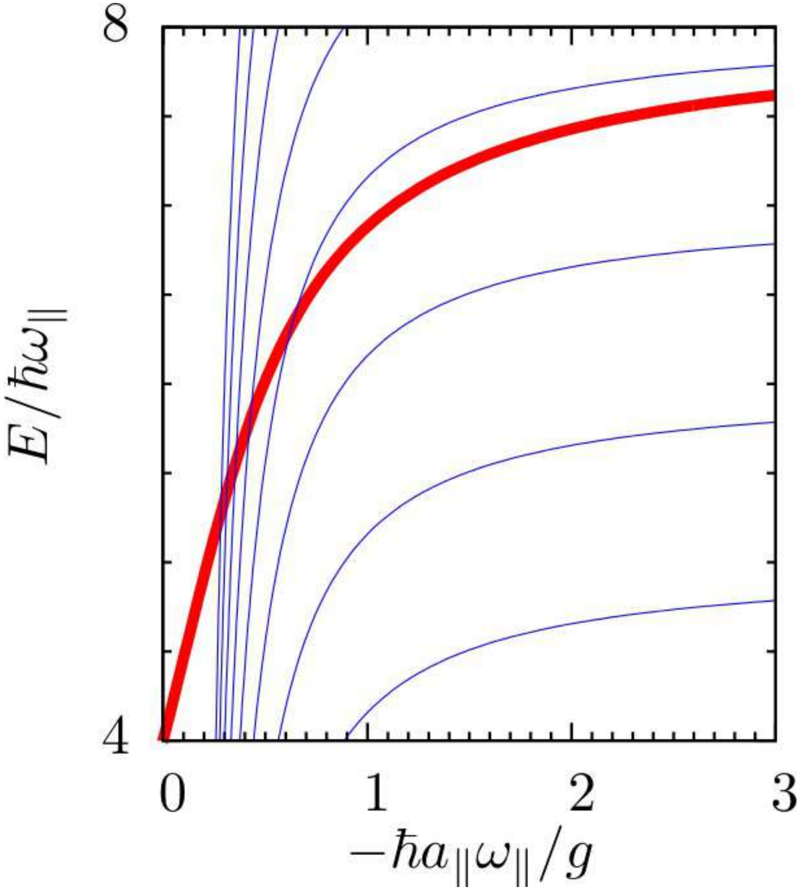


Loss affected region

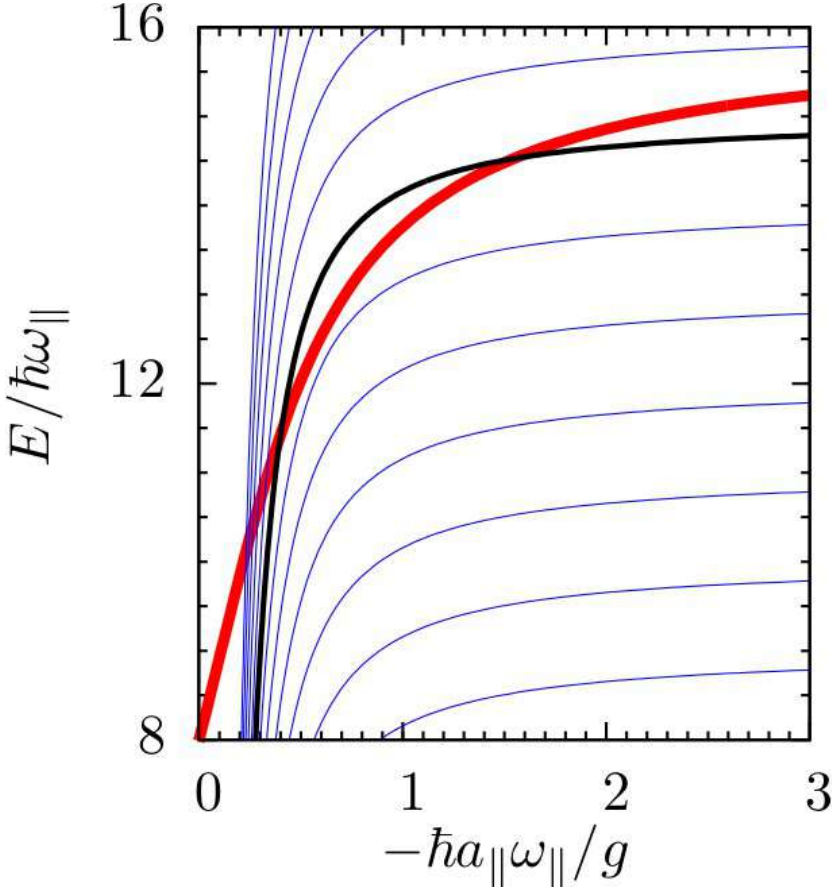


Band crossings

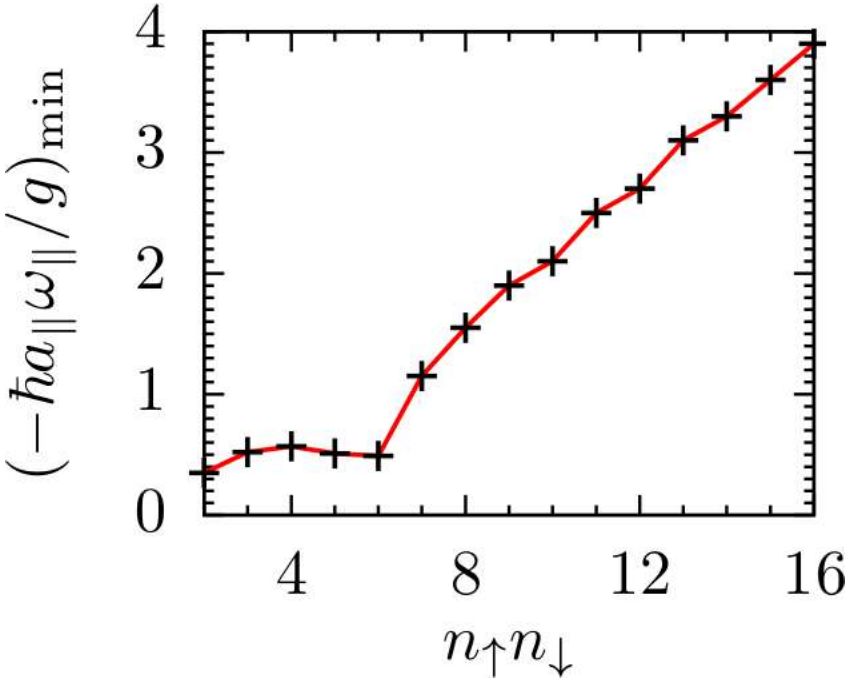
$n_\uparrow n_\downarrow = 4$



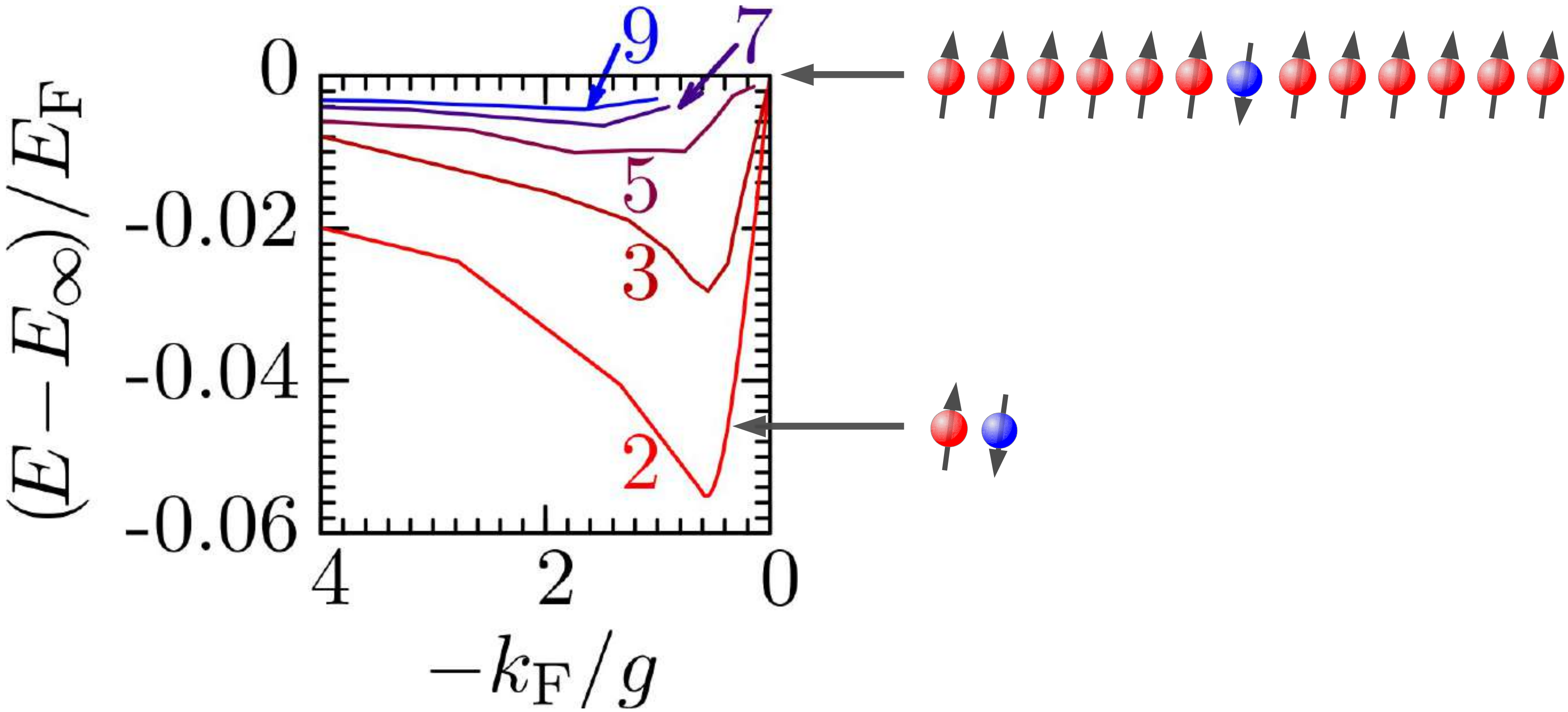
$n_\uparrow n_\downarrow = 8$



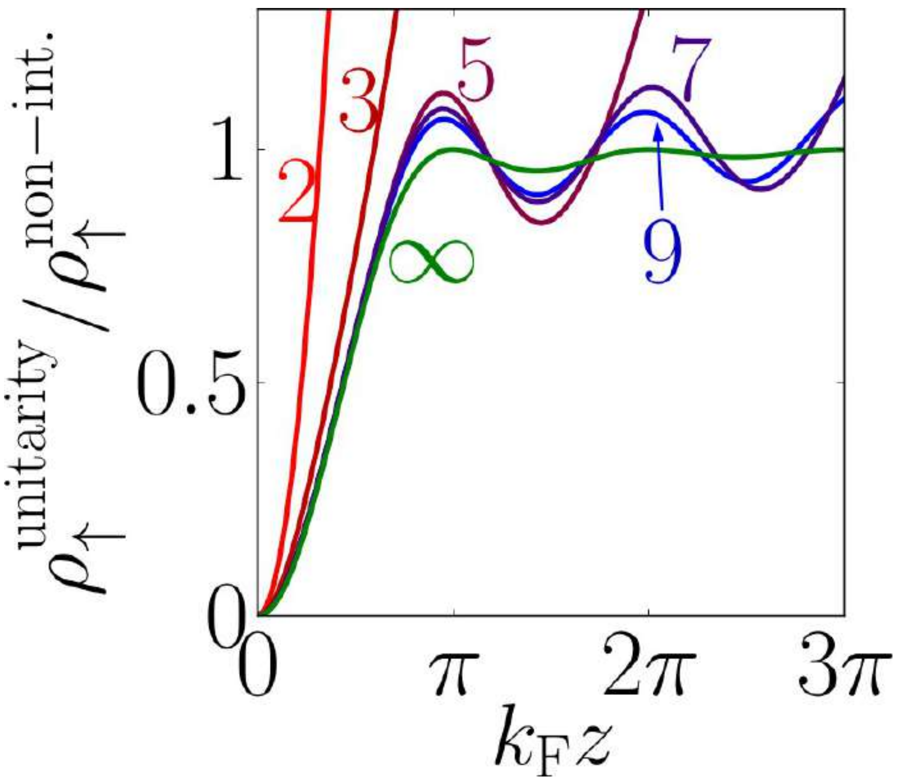
Band crossings



System size dependence



System size dependence



Summary

Few-fermion system displays ferromagnetic correlations

Tunneling probability of ½ due to degenerate triplet states

Losses restriced to narrow range of interaction strengths