Transport of ultracold atoms in an accelerated optical lattice

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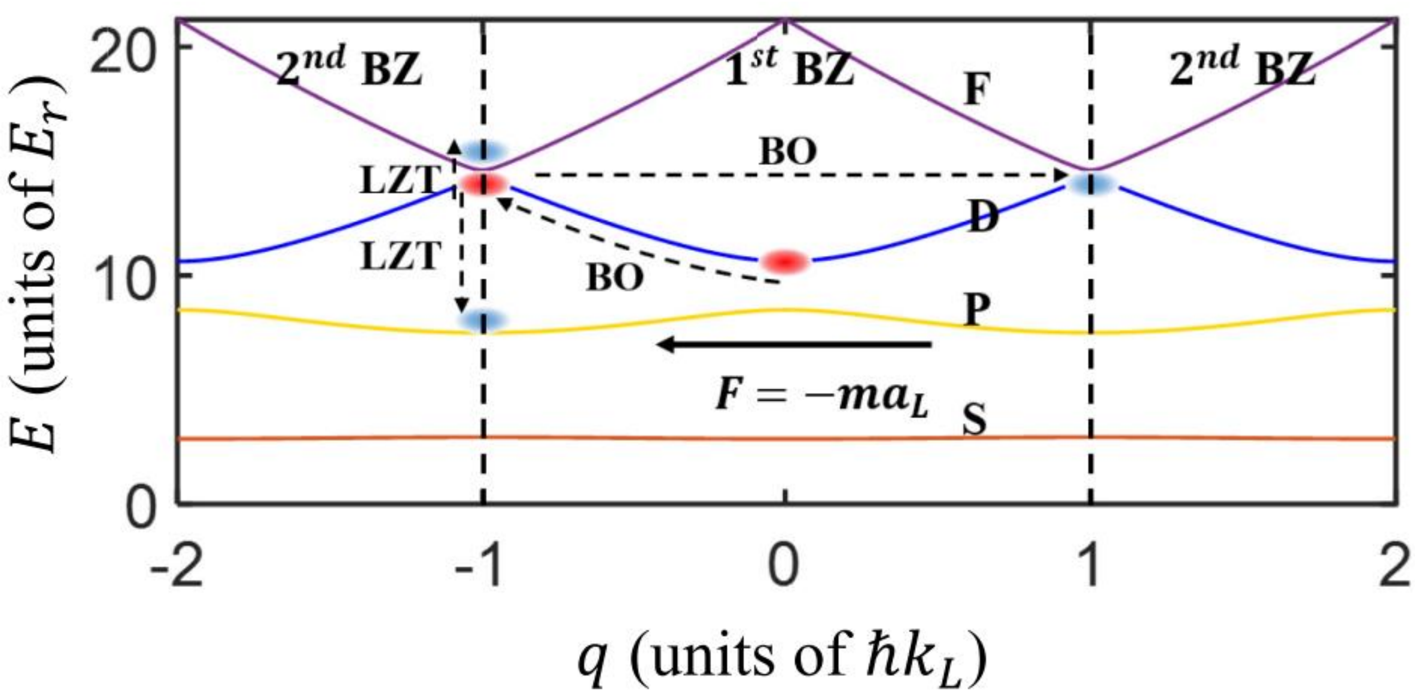
Transport process of atoms in a moving optical lattice



- **The noninteracting atoms in a constantly accelerated lattice can be described by a single-particle Hamiltonian,**

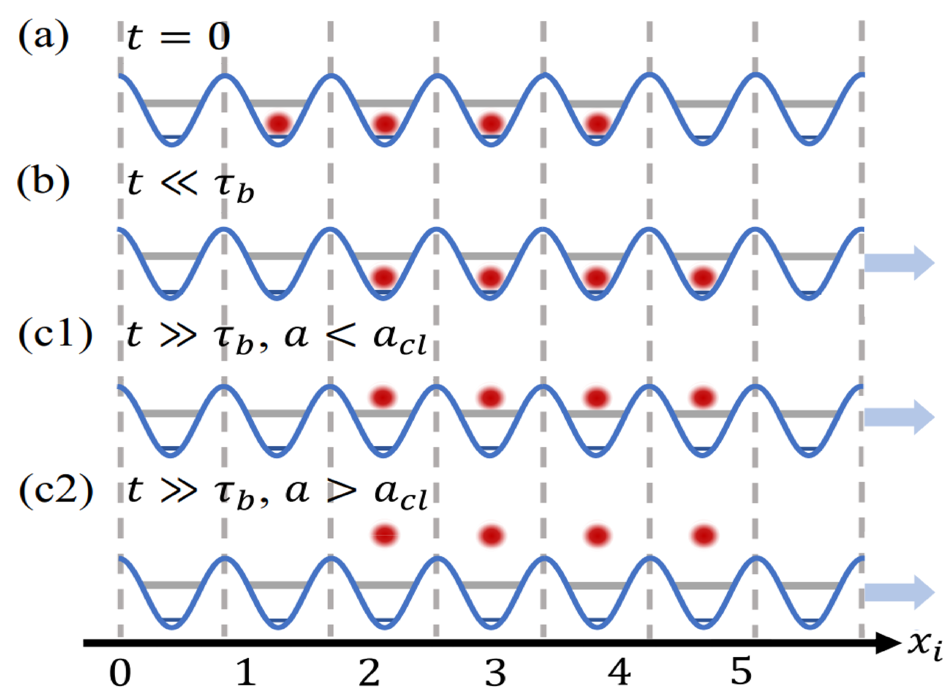
$$H=\frac{\hat{p}^2}{2m}+\frac{V_0}{2}\sin\left(2k_L\left(x-\frac{at^2}{2}\right)\right).$$

- **the adiabatic condition for the Hamiltonian:**

$$t \ll \tau \triangleq \sqrt{8\,Er/V_0k_La},$$

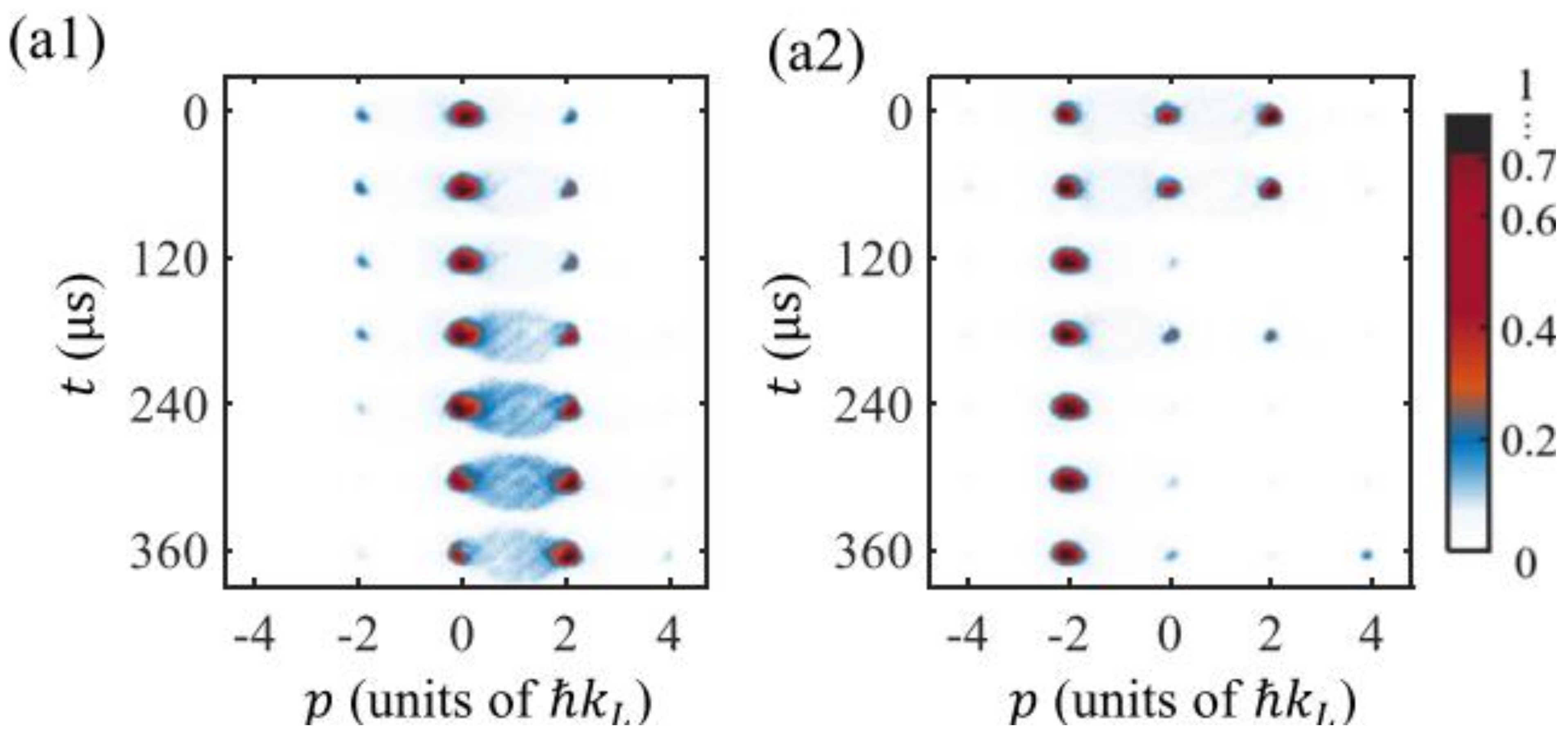
where τ is defined the time bound.

The relation between time bound and escape mechanisms.



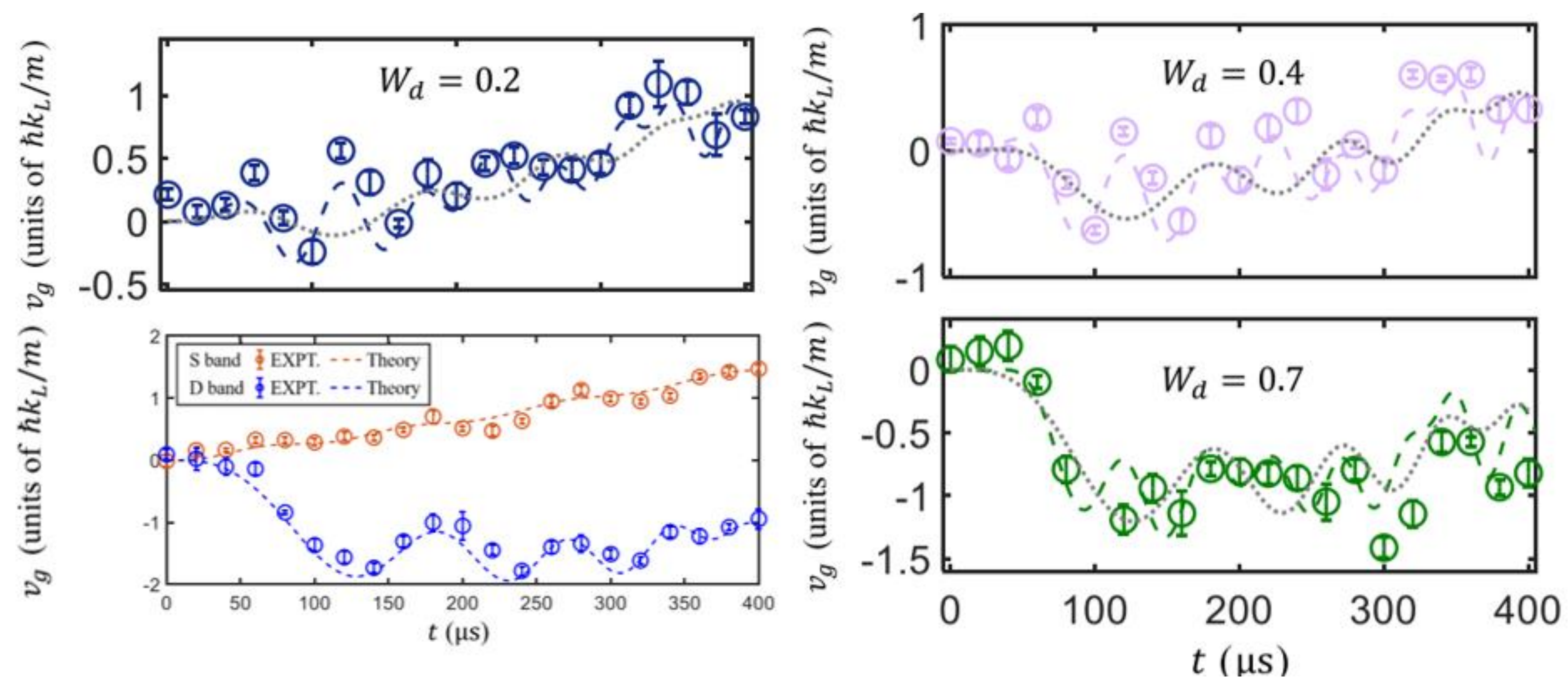
- Within the time bound, the atoms are trapped and accelerated [shown in (b)] . When the evolution time exceeds the time bound, the atoms can populate either in higher bands [shown in (c1)] or in the free space [shown in (c2)] . [shown in (c1)]

Transport process of atoms at high bands in a moving optical lattice



- **The group velocity of atoms at the D band is opposite to that at the S band.**
- **By preparing superposition states with different superposition weights $W_d = N_D/(N_D+N_S)$ of the D-band and S-band atoms, manipulation of atomic group velocity from positive to negative is realized.**

- The transport process of atoms at the S band and D band. (a1) and (a2) are the absorption images of transport process of S-band and D-band atoms, respectively. (b) The blue (lower) data and orange (upper) data show the evolution of group velocity vg of the D-band atoms and S-band atoms.



[1]Yin et. al., Phys. Rev. A 108, 033310
[2]Yu et. al., Phys. Rev. A 107, 023303