Floquet Three-level notes

Ning Sun

(Dated: August 6, 2016)

PARAMETERS

- Energy levels scales
  - Total band width of the lowest two bands: $h \times 3.9(1)kHz$
  - Gap to the next higher band: $h \times 5.4(2)kHz$
    [Esslinger 2014, Haldane model]
- Shaking parameters
  - Shaking frequency: "Using lattice shaking at a frequency near the ground-band to first-excited-band transition", $\omega = 7.3kHz = 5.5E_R/\hbar$
  - Shaking amplitude: $b = 65nm$ ($\lambda_L = 1064nm$)
    $\Rightarrow \gamma \sim \omega b/\lambda_L = 5.5E_R \times 0.06 = 0.33E_R = 0.44kHz$
    [Chen Ching 2013, Nat.Phys., Effective ferromagnetic]

RATE OF CONVERGENCE

$\Delta_1 = 1, \Delta_2 = 10$

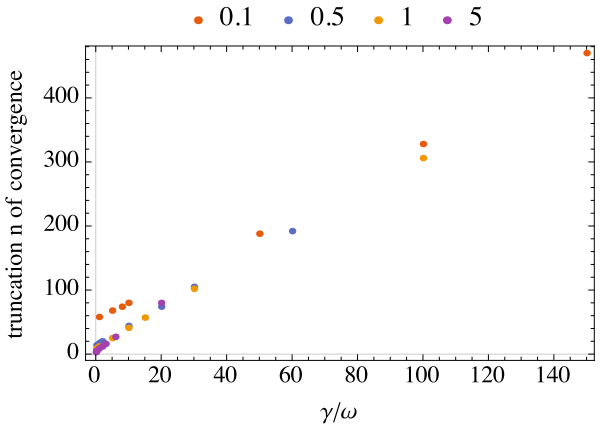
TABLE I: rate of convergence for the energy levels (truncation n) [accuracy:10^{-4}]

$\hbar\omega$ \ γ	0.1	0.5	0.8	1	5	10	15	30	100
0.1	58	68	74	80	188	328	470	896	
0.5	14	17	19	20	44	74	105	192	595
1	8	10	11	12	25	41	57	102	306
5	3	4	5	5	9	12	16	27	80
10	3	3	4	4	7	9	11	16	40
15	3	3	3	3	5	7	9	13	29
30	3	3	3	4	5	6	7	9	18
100	3	3	3	3	4	4	5	6	10

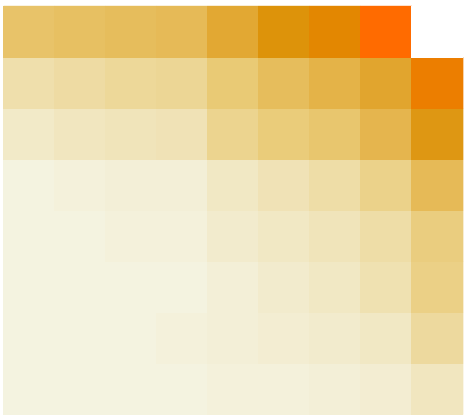
Of the rate of convergence of truncation, two statements could be made:

1. The rate of convergence depends on γ/ω. Precisely, the truncation n of Floquet matrices depends linearly on γ/ω.

2. But n should be large at least than $(\Delta_1 + \Delta_2)/\omega$ to make the truncation series convergent.



(a)for different ω, $n \sim \gamma/\omega$



(b)Matrix plot of Table 1

Suppose the relation between n and γ/ω is linear dependence $y = a + bx$. Fit the data gives

TABLE II: Fitting $n = a + b(\gamma/\omega)$

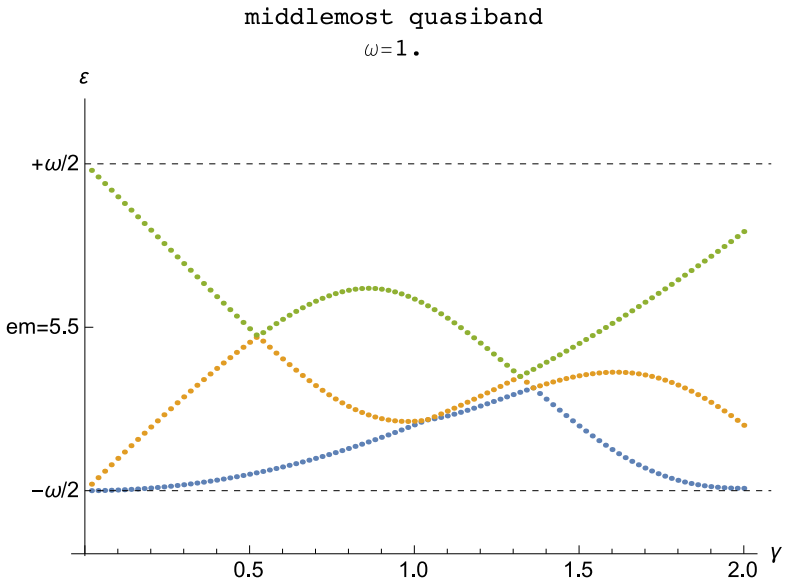
ω	0.1	0.5	1	5	10	15	30	100
a	51.44	15.15	9.88	4.75	5.56	5.73	5.09	
b	2.81	2.91	2.97	3.76	3.45	3.50	3.87	

AVOIDED CROSSING

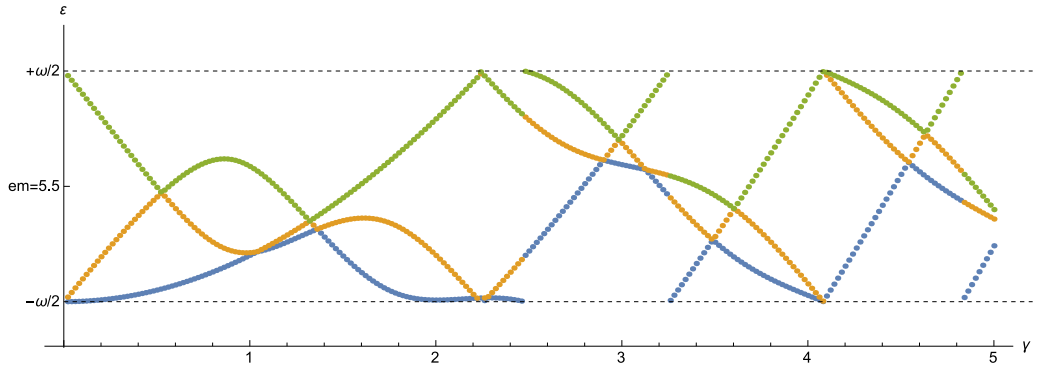
For several shaking frequency ω, we plot quasi-energy spectrum vs γ.

Based on the study of the pattern of quasi-energy spectrum vs γ, we make the following statement:

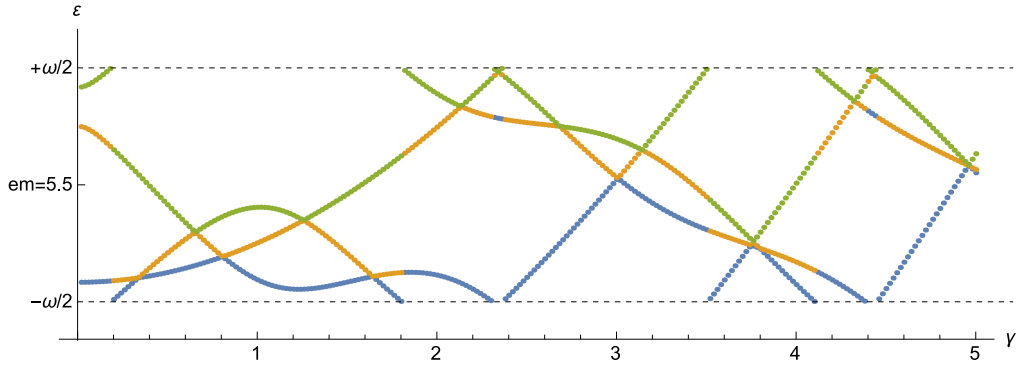
- Generally there should be some avoided crossing. When ω is large, large value of γ is needed to make it happen.


middlemost quasiband
ω=1.
ε
+ω/2
em=5.5
−ω/2
0.5
1.0
1.5
2.0
γ

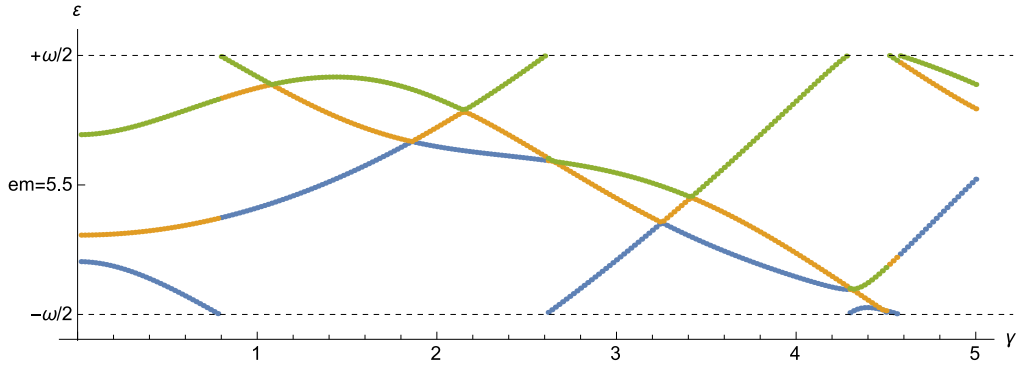
middlemost quasiband
ω=1.



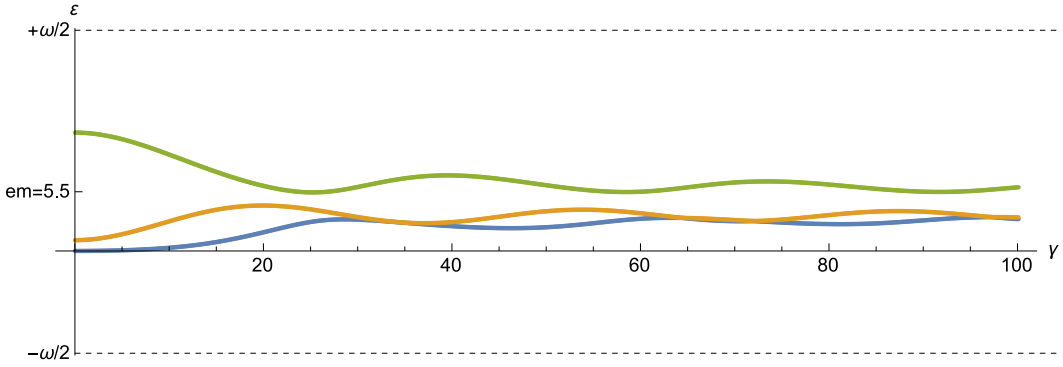
middlemost quasiband
ω=1.2



middlemost quasiband
ω=1.96

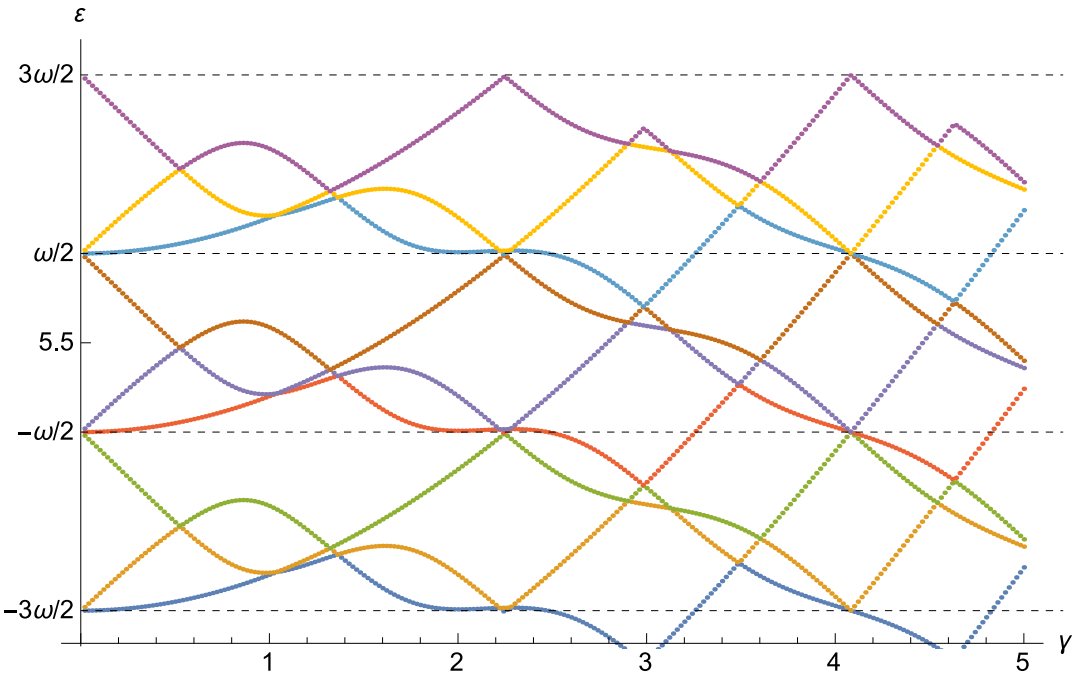


middlemost quasiband
ω=30



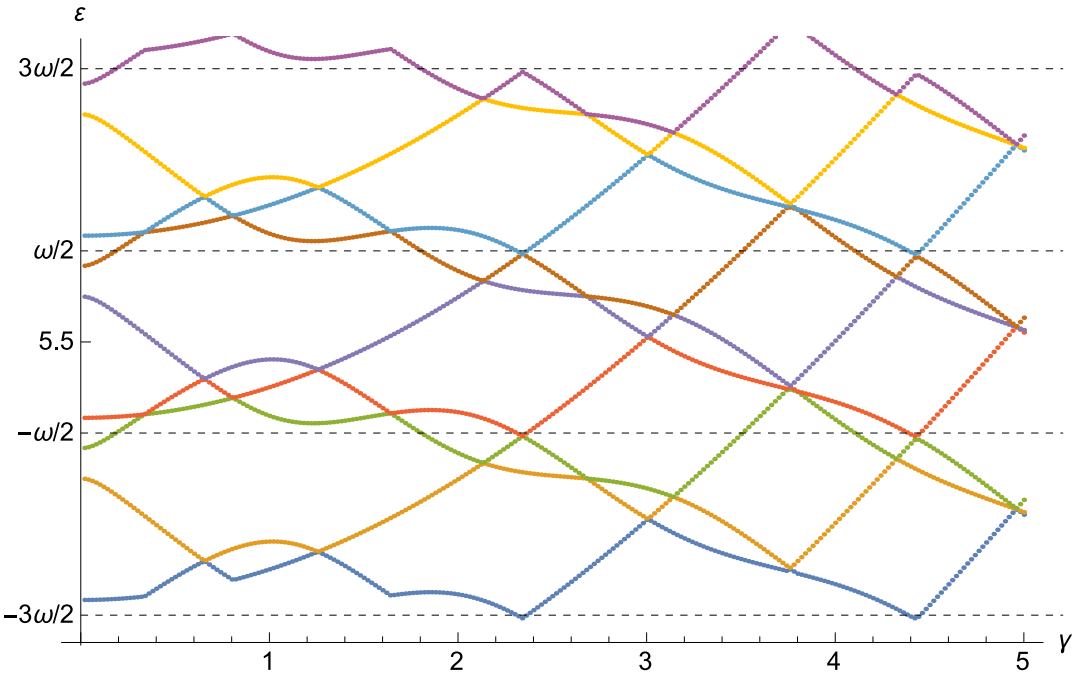
middlemost 3 quasibands

ω=1.



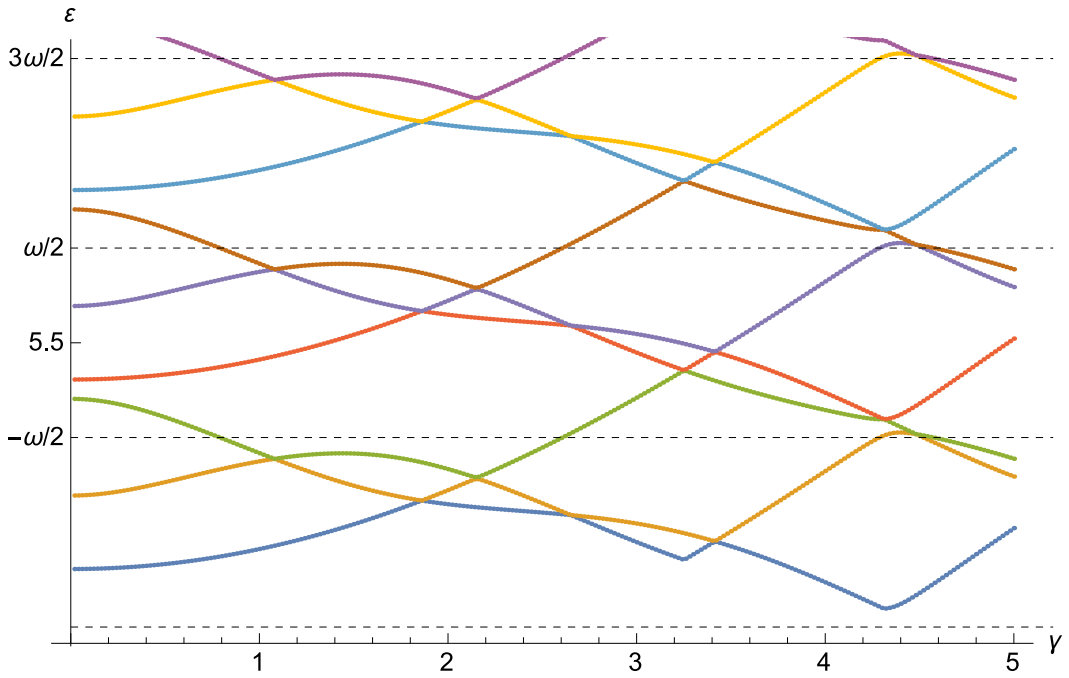
middlemost 3 quasibands

ω=1.2



middlemost 3 quasibands

ω=1.96



middlemost 3 quasibands

ω=30