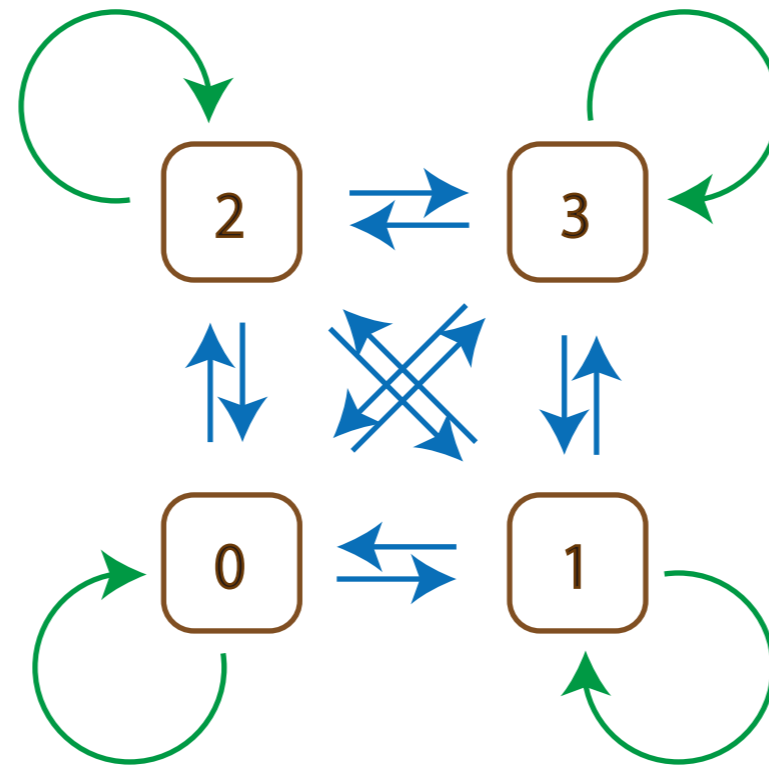




上田研 ゼミ

# Hybrid系の運動について (II)

—flowとtransitionの時系列を求める—



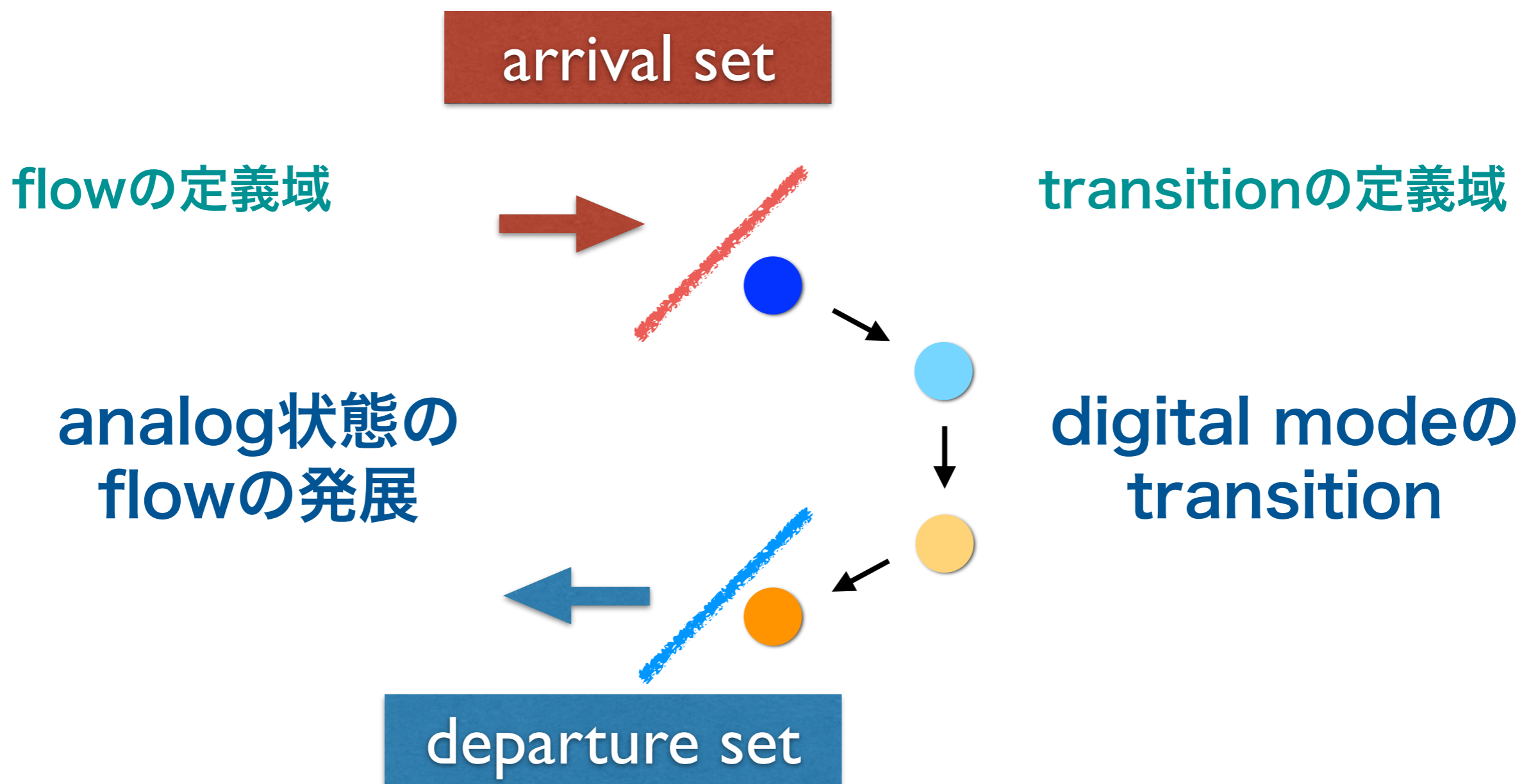
川上 博

2014(H26).05.23



# Hybridの運動とは？

運動 = flowとtransitionの時系列



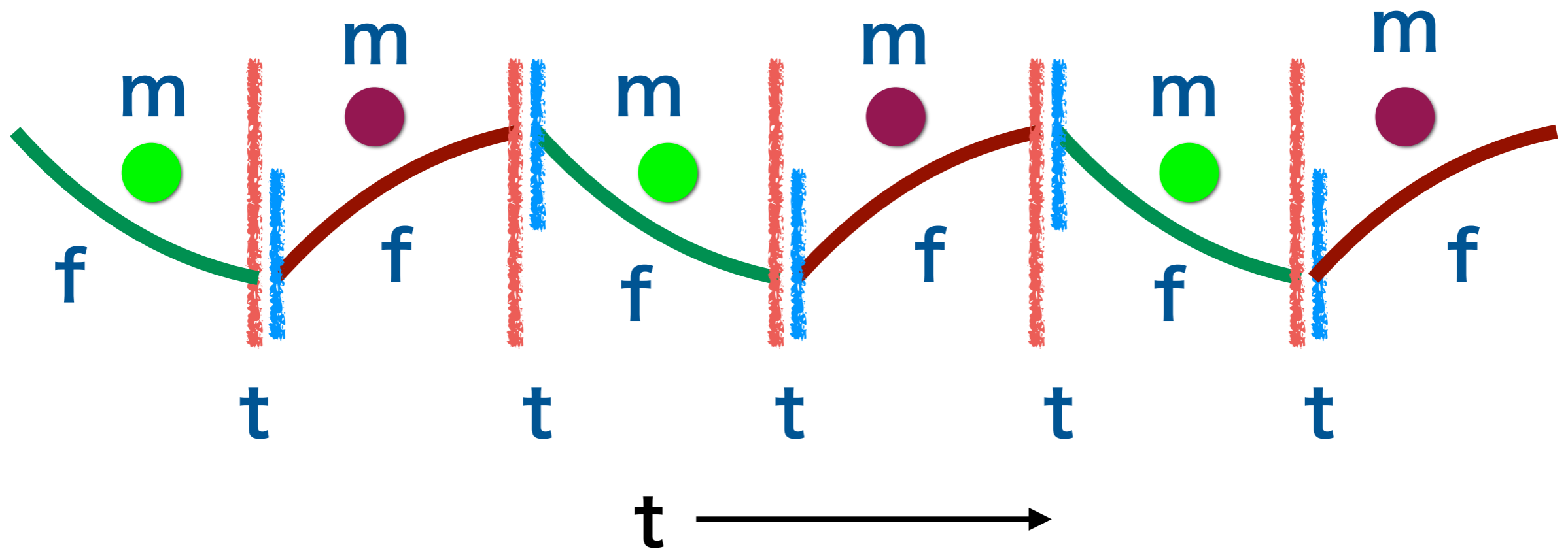


# Hybrid系の状態の時系列

f: flow    t: transition

ftftftft...

flowとtransitionの繰り返し

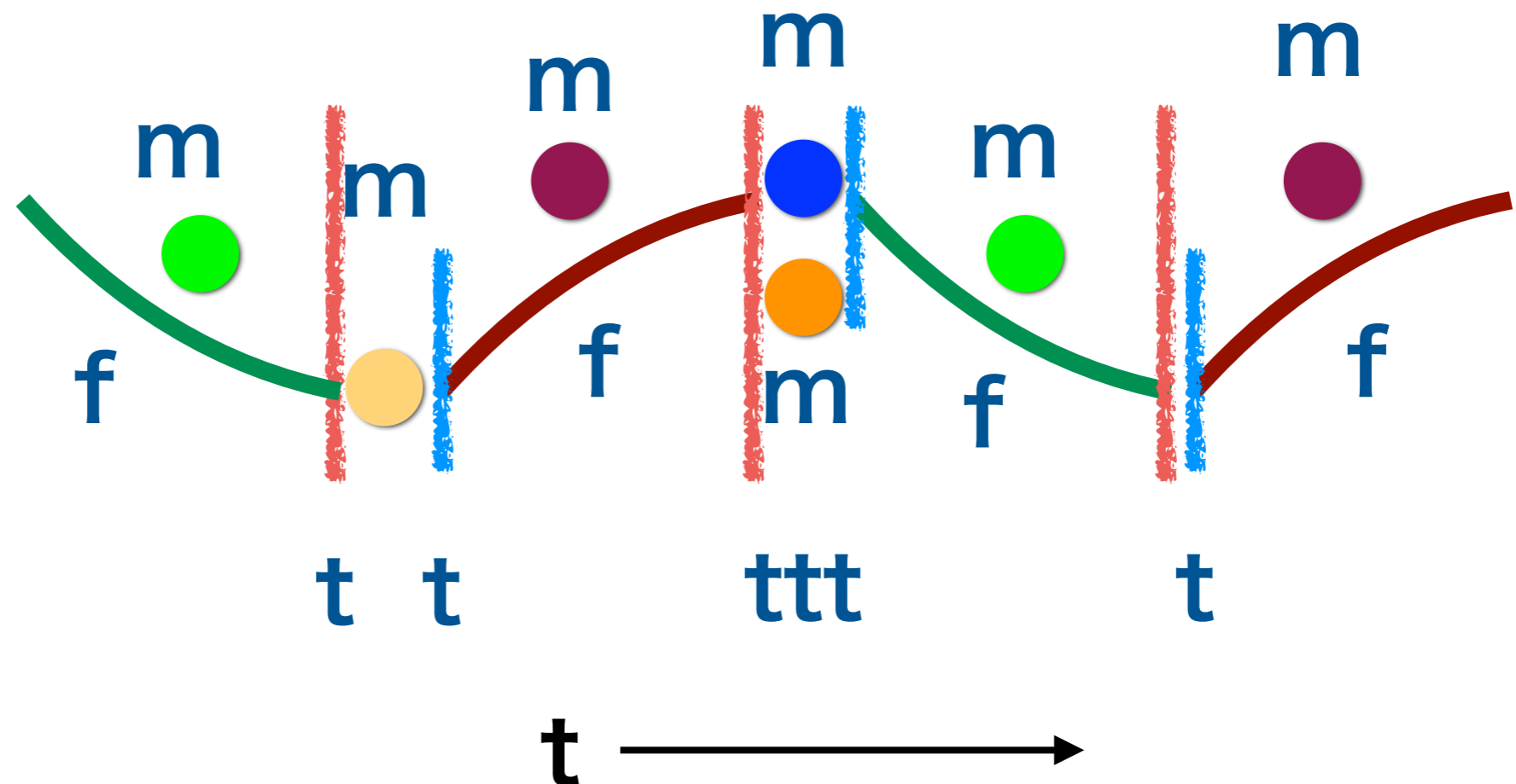




# Hybrid系：状態の進展と遷移

flowが進展している時は、modeは固定されている  
 modeが遷移している時は、flowは固定されている  
**meta-stable state**

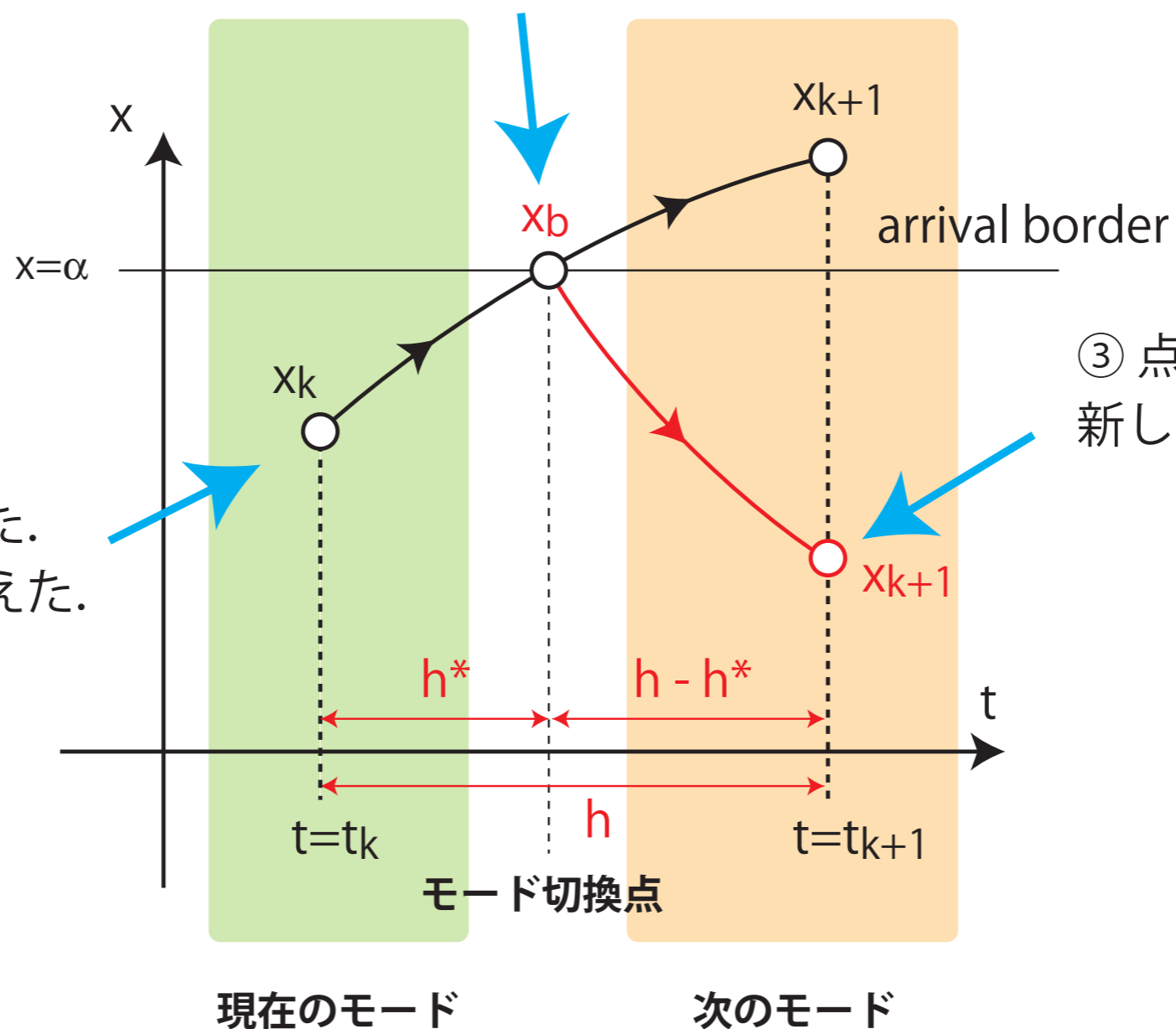
fttftttft...





# border近傍での運動 (I)

② キザミ  $h^*$  を求め, arrival border  $\alpha$  上の点  $x_b$  を求める.

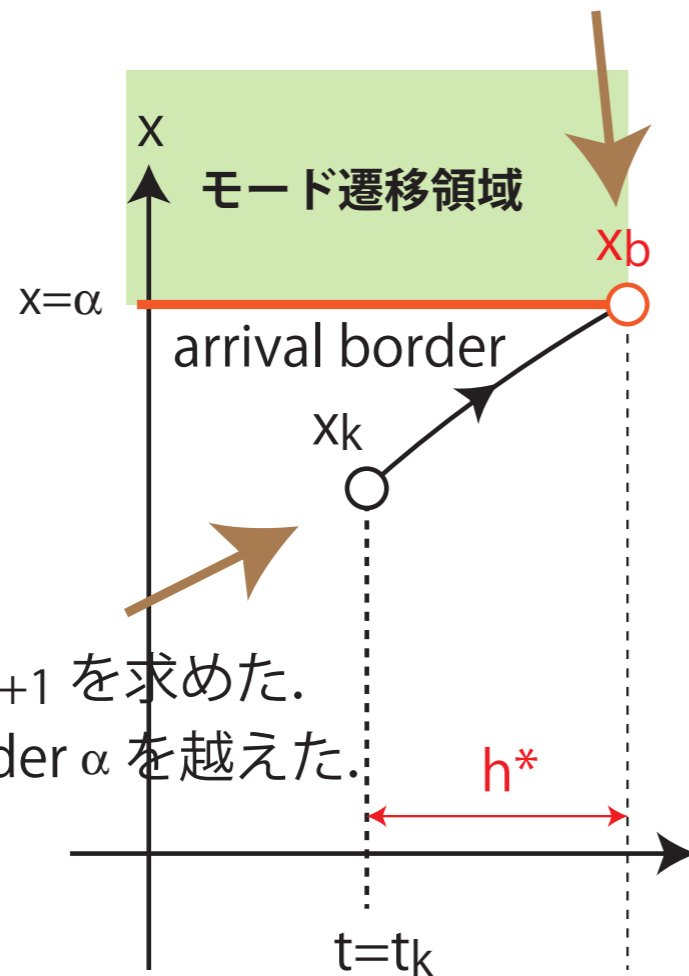




## border近傍での運動 (II)

② キザミ  $h^*$  を求め, arrival border  $\alpha$  上の点  $x_b$  を返す.

③  $x_b$  がベクトル場の定義域に入るまでモードを遷移させる.

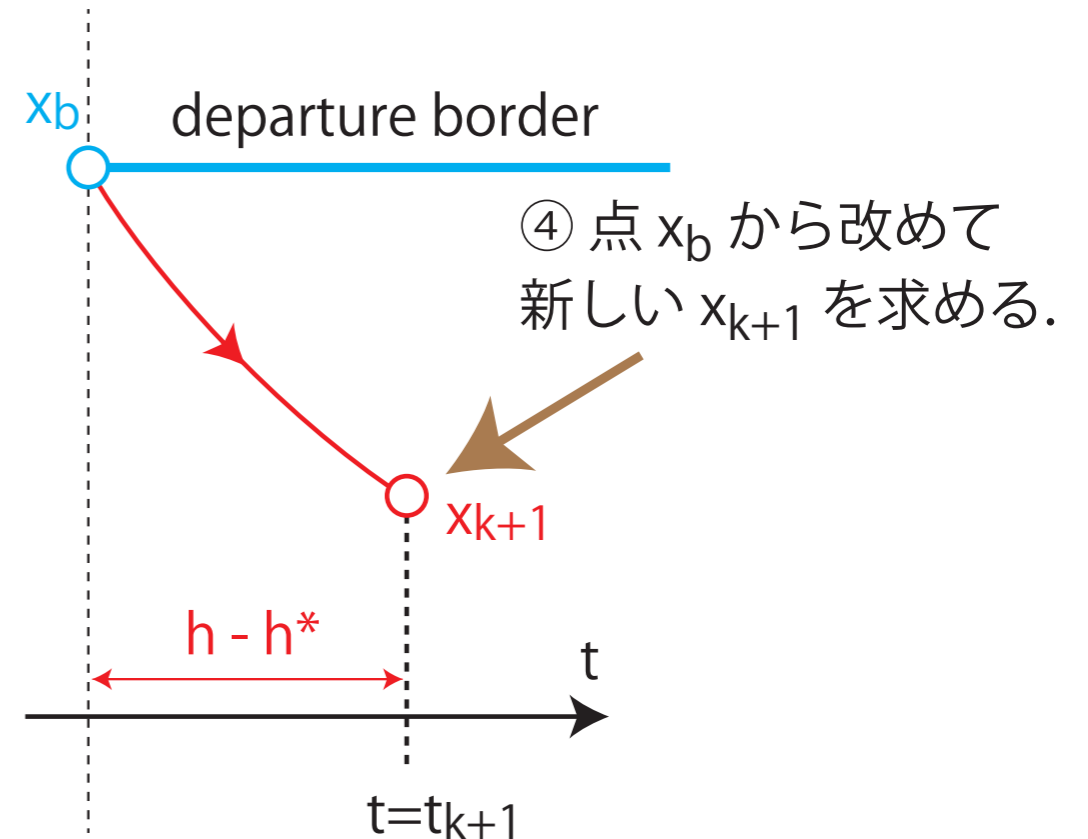


①  $t=t_k$  で  $x_{k+1}$  を求めた.  
 $x_{k+1}$  が border  $\alpha$  を越えた.

phase flow による発展

modeEvent(q, x)  
モード遷移関数

mode 遷移による発展

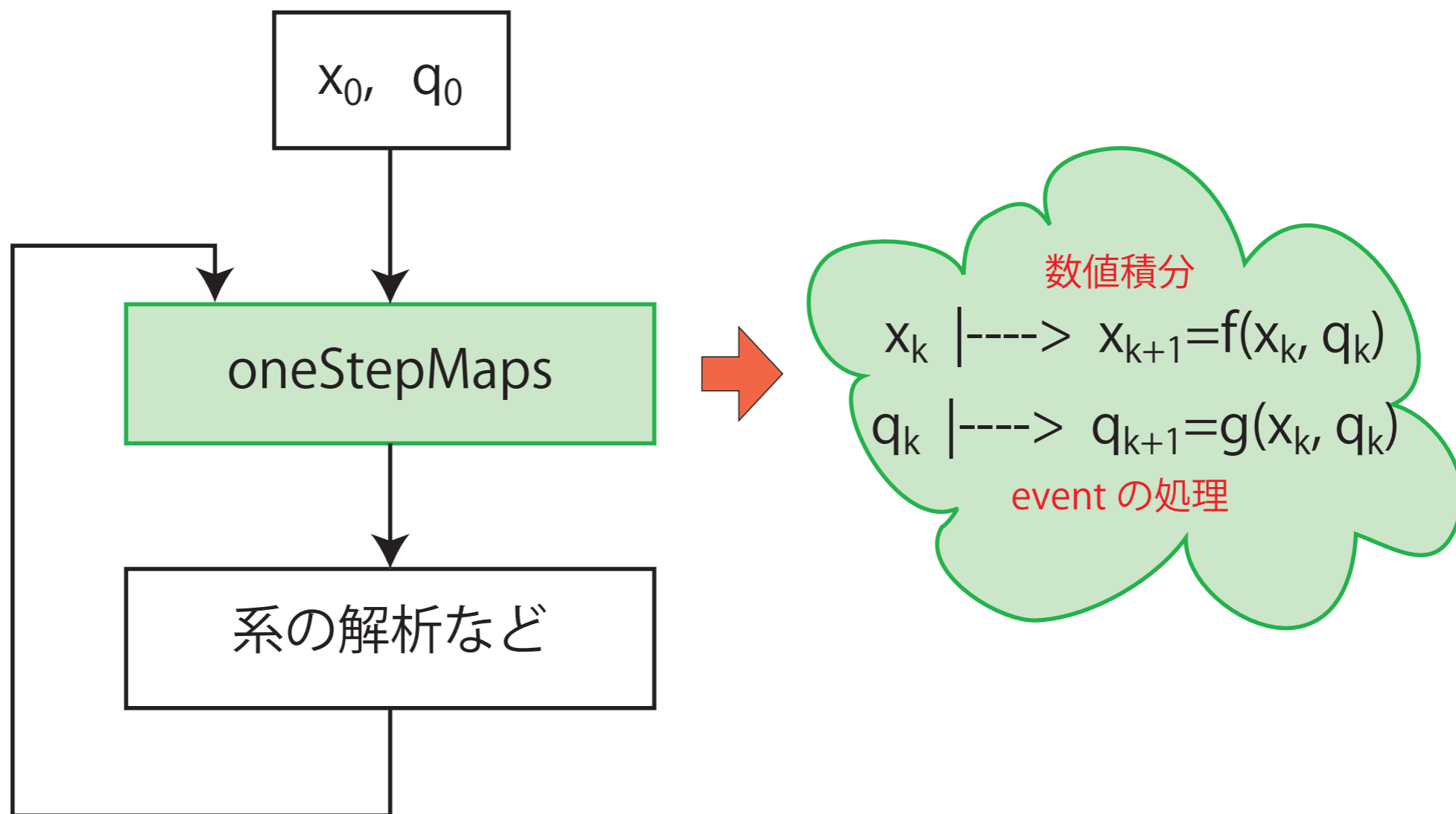


④ 点  $x_b$  から改めて新しい  $x_{k+1}$  を求める.

phase flow による発展

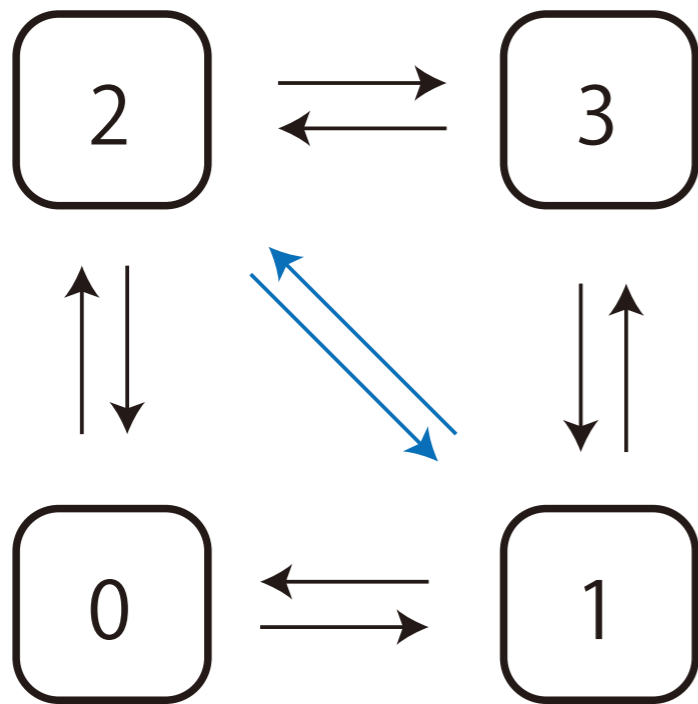


# oneStepMaps : 1 単位時間の発展

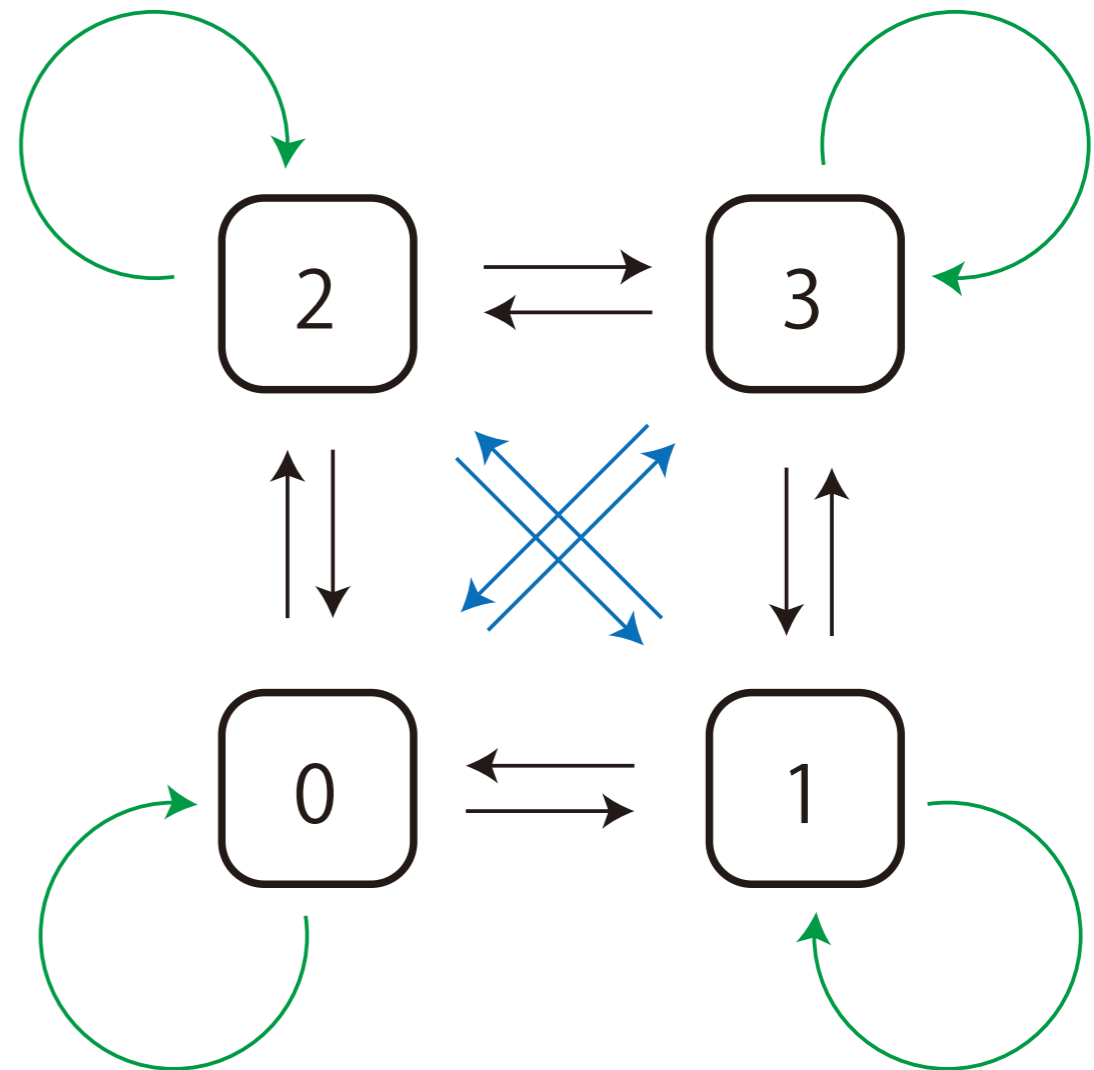




# LEDホタル相互結合系 : A1

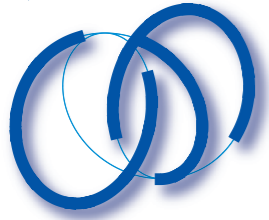


(a) 遷移図 (従来のモデル)

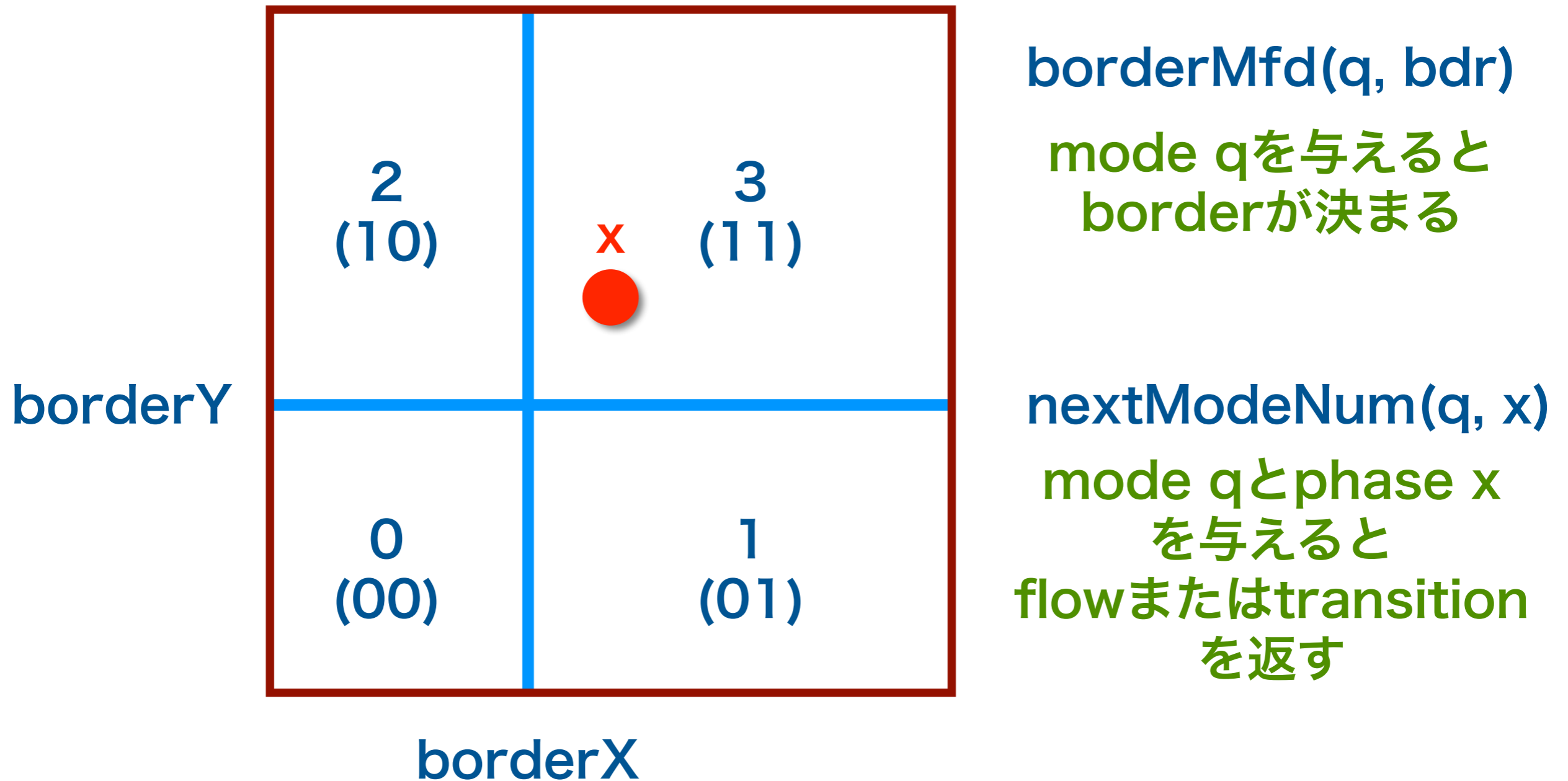


(b) 遷移図 (今回のモデル)





# phase plane: region number (flow region vs transition)





## next transition number

1 (01)	2	3	0 (00)
3 (11)	0	1	2 (10)

**borderMfd(q, bdr)**

mode qを与えると  
borderが決まる

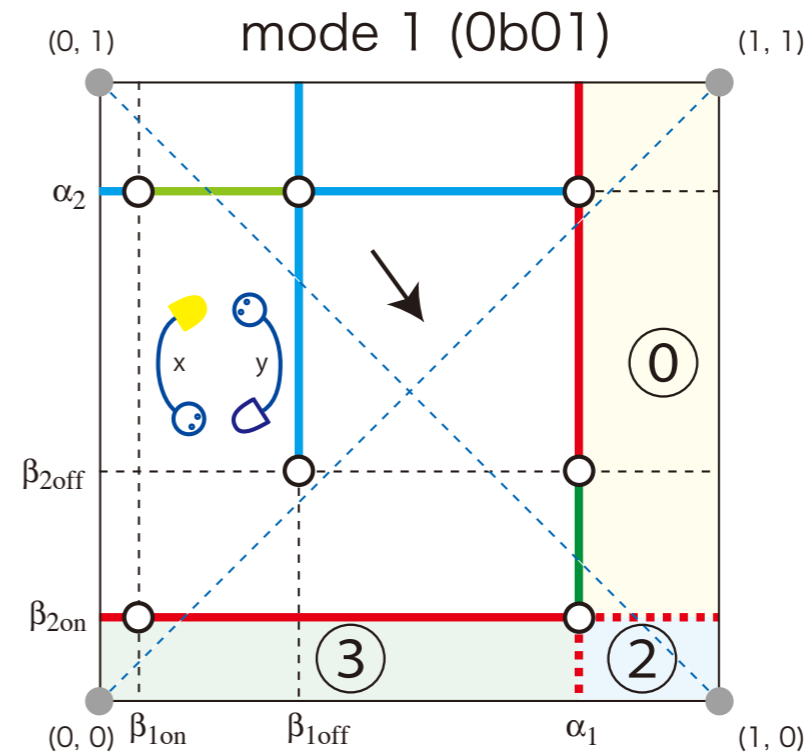
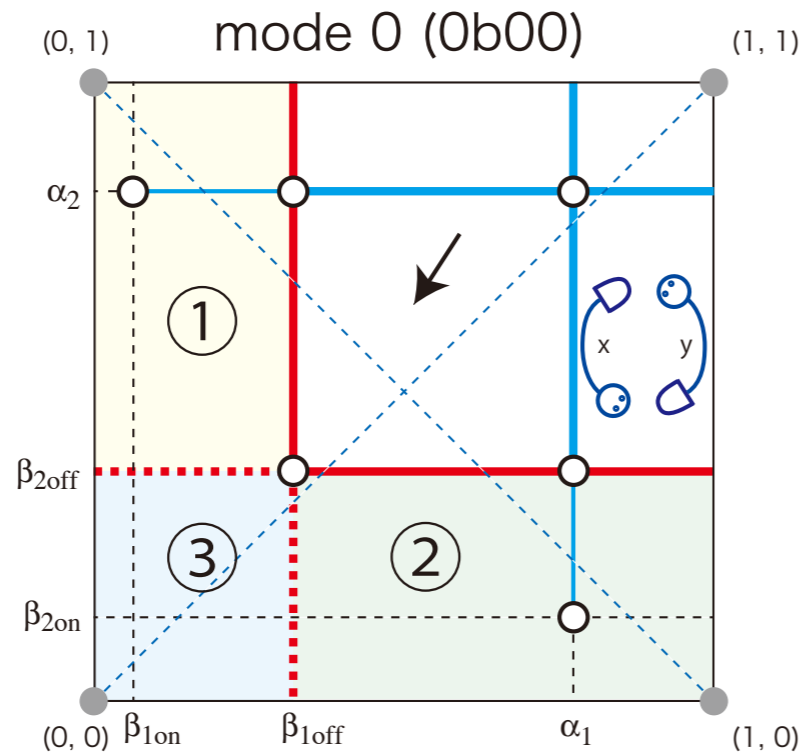
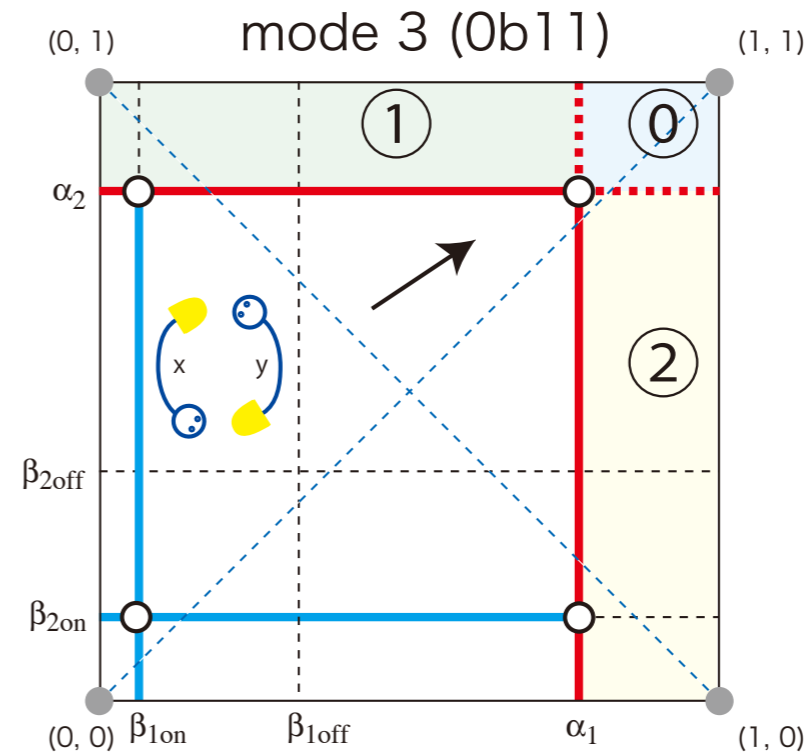
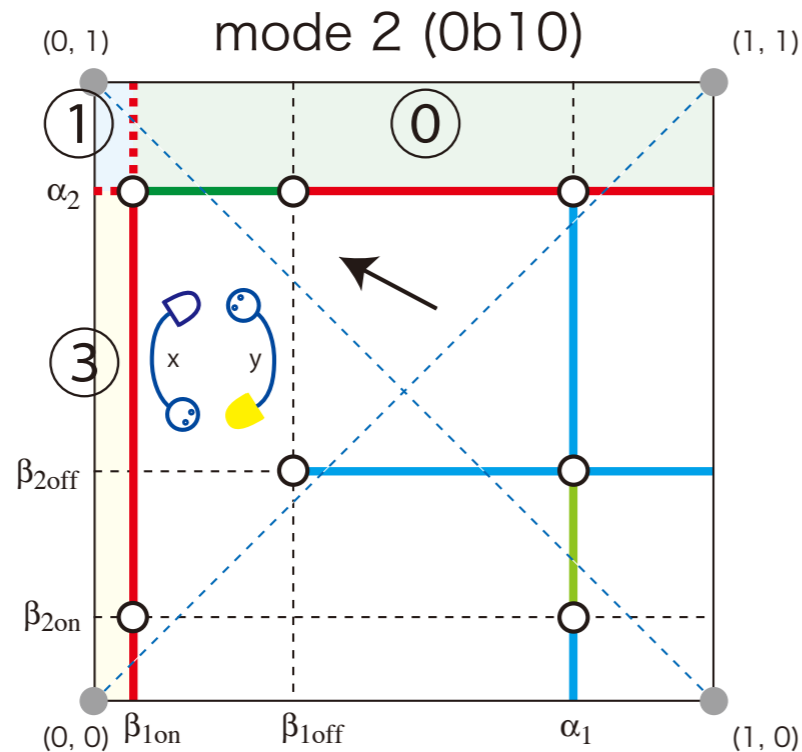
**nextModeNum(q, x)**

mode qとphase x  
を与えると  
flowまたはtransition  
を返す

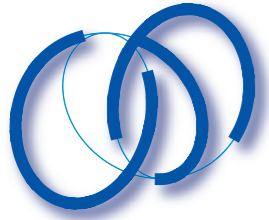
**next transition number = region number**



# type A1-A1 circuit : phase portrait



— arrival set     
 — departure set     
 — codimension 2 property



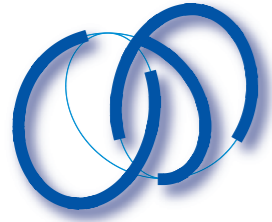
```
void borderMfd(unsigned int q[], double bdr[]){
    unsigned int mode;

    mode=q[1]*2+q[0];
    switch (mode) { // A1-A1 characteristics
        case 0:
            bdr[0]=betaXoff;
            bdr[1]=betaYoff;
            break;
        case 1:
            bdr[0]=alphaXoff;
            bdr[1]=betaYon;
            break;
        case 2:
            bdr[0]=betaXoff;
            bdr[1]=alphaYon;
            break;
        case 3:
            bdr[0]=alphaXoff;
            bdr[1]=alphaYoff;
            break;
        default:
            break;
    }
}
```

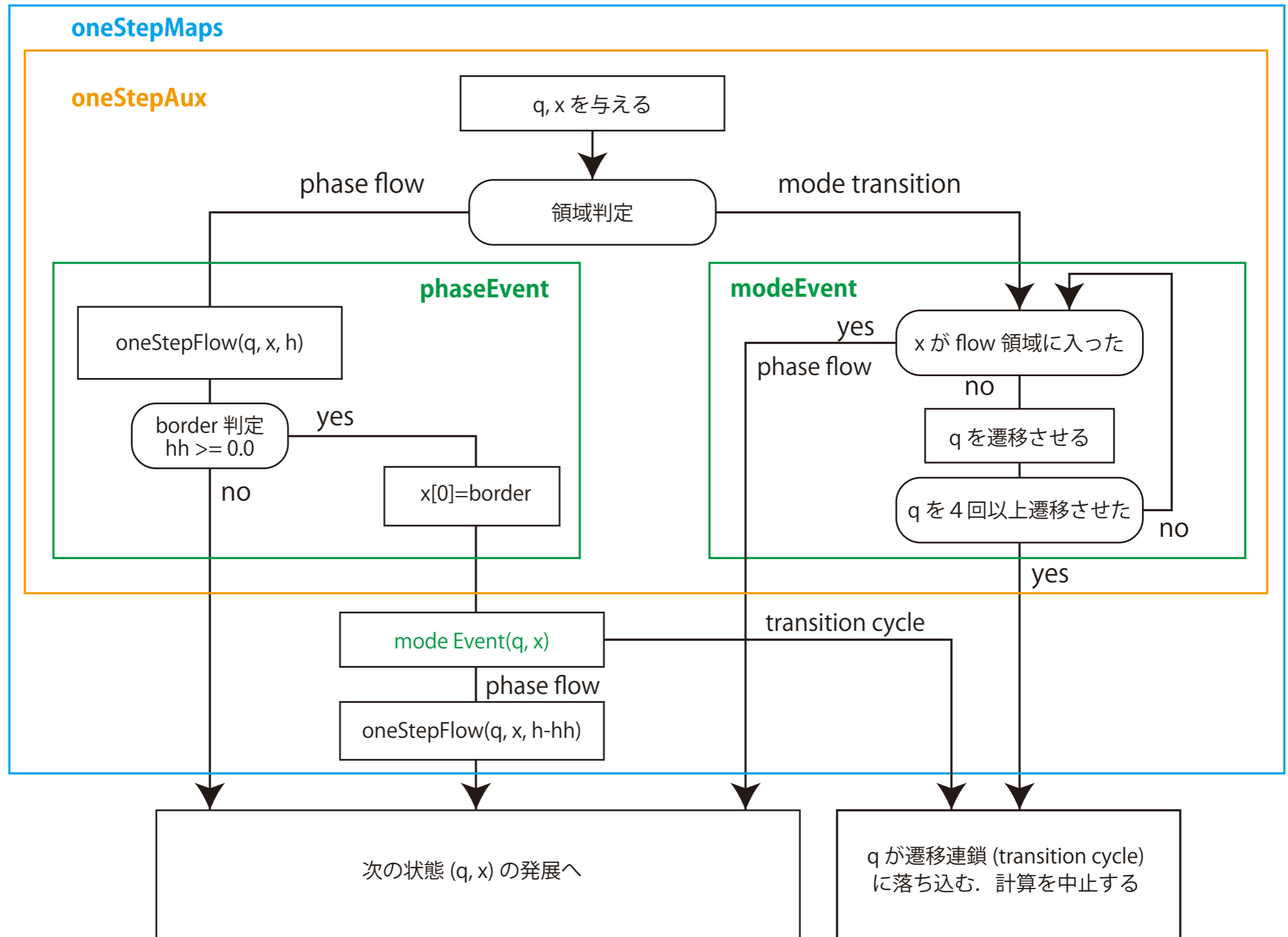


```
unsigned int nextModeNum(unsigned int q[], double x[]){
    unsigned int nextMode;
    double border[2];

    borderMfd(q, border);
    if (x[0]<border[0]) {
        if (x[1]<border[1]) { // region 0
            nextMode=3;
        }else{ // region 2
            nextMode=1;
        }
    }else{
        if (x[1]<border[1]) { // region 1
            nextMode=2;
        }else{ // region 3
            nextMode=0;
        }
    }
    return nextMode;
}
```



# ハイブリッド系の oneStepMaps の流れ図





```

void oneStepAux(unsigned int q[], double x[], double *hh, int *nn){
    unsigned int cmode, nmode;

    nmode=nextModeNum(q, x);
    cmode=q[1]*2+q[0];
    if(cmode==nmode){ // phase event
        *hh=phaseEvent(q,x);
    }else{
        *nn=modeEvent(q,x);
    }
}

```

```

void oneStepMaps(unsigned int q[], double x[], double *hh, int *nn){

    oneStepAux(q, x, hh, nn);
    if (*hh>=0.0) {
        *nn=modeEvent(q, x);
        NSLog(@"%d %d %f %d %f\n", q[0], q[1], x[0], q[1]*2+q[0], *hh);
        oneStepFlow(q, x, h-(*hh));
    }
}

```



# 関川先生の質問

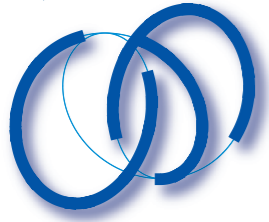
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**質問 1 : 回路実験と数値解析で波形に一致しない箇所がある**

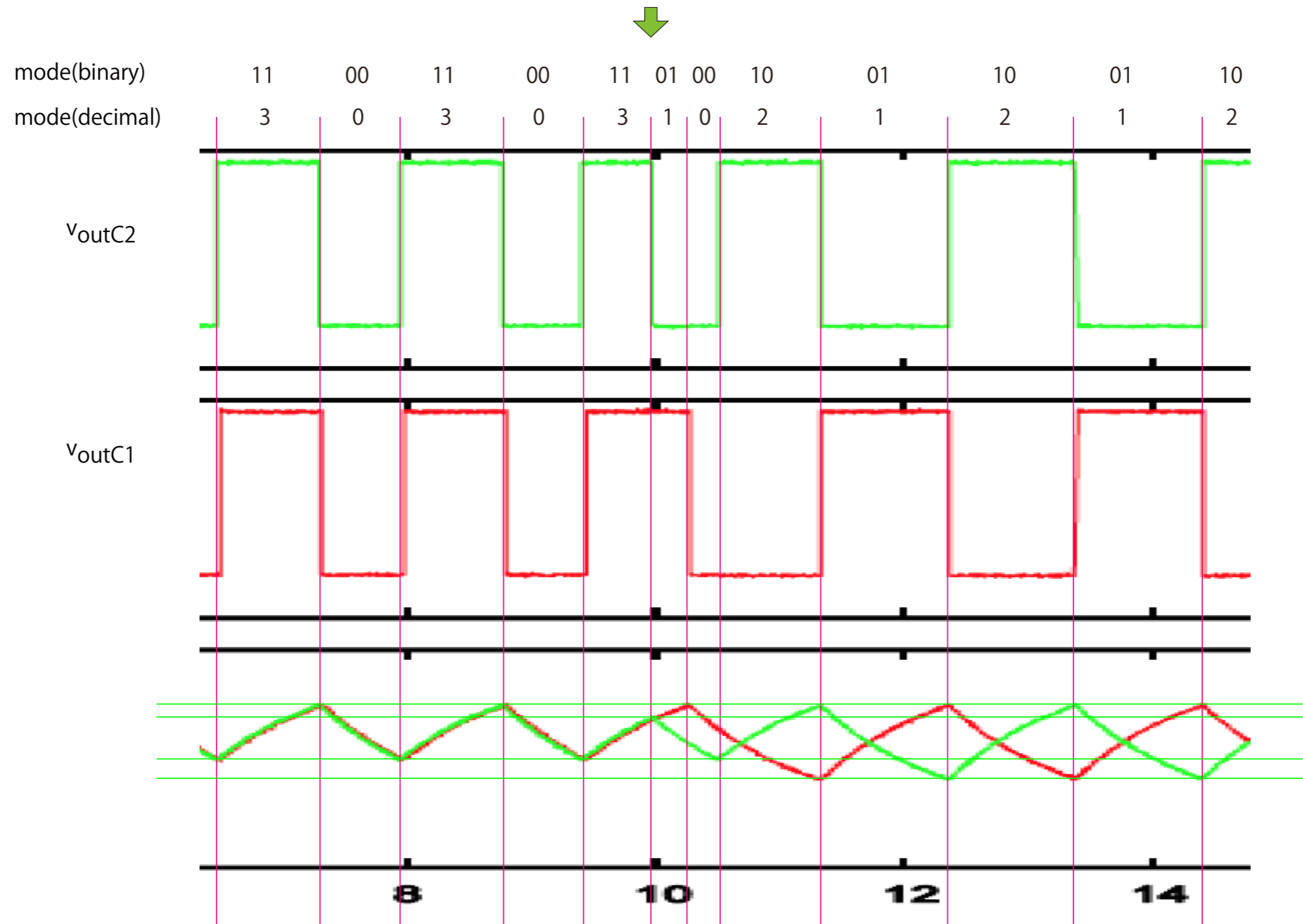
**data 1: CI-CI coupling**

**data 2: AI-CI coupling**





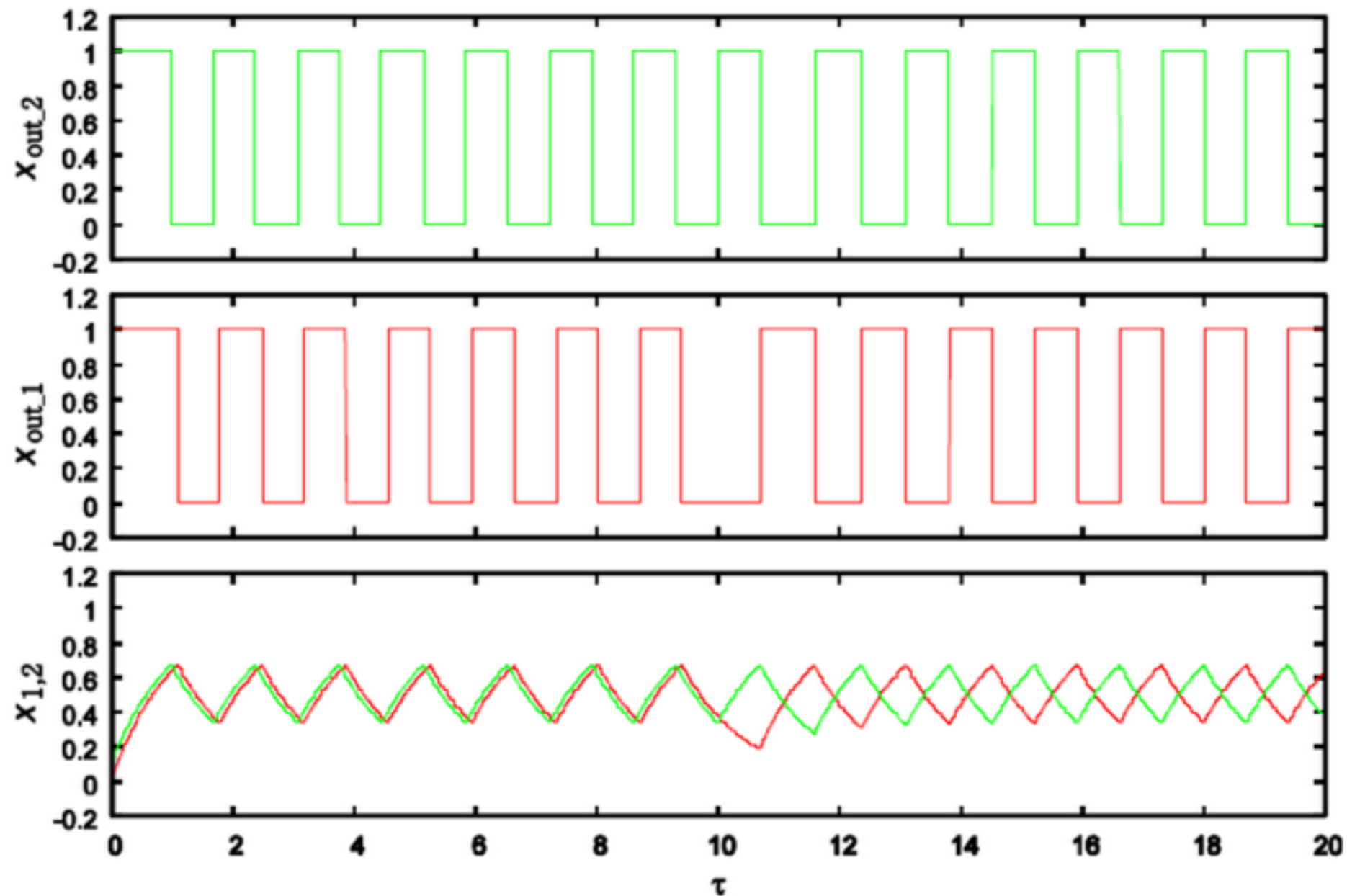
typeC-typeC coupled system(Experimental results) p. 14  
in ExperimentalResults\_20120402.pdf

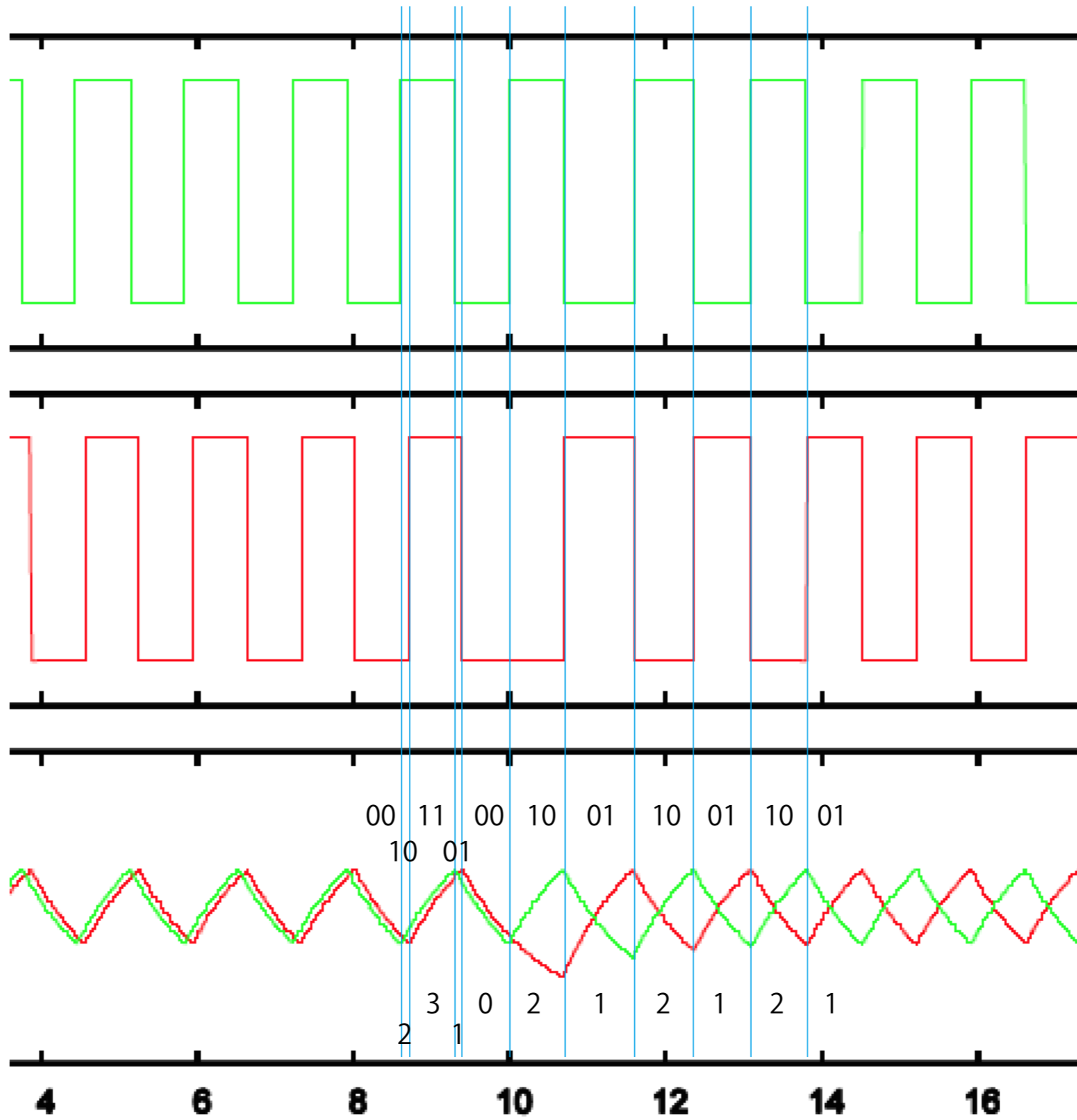


**310212121...**



# typeC-typeC coupled system (Numerical simulation)



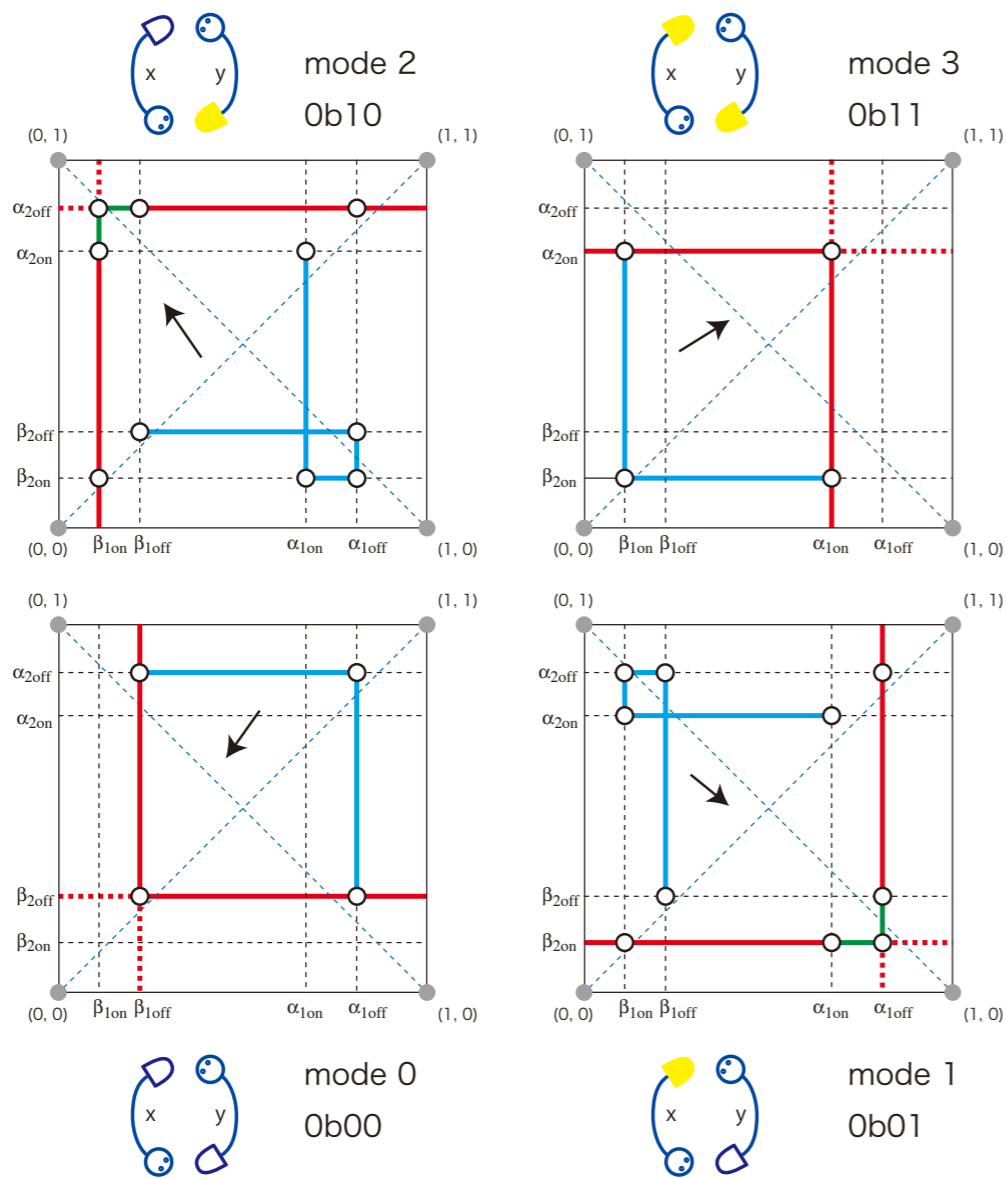


**310212121...**

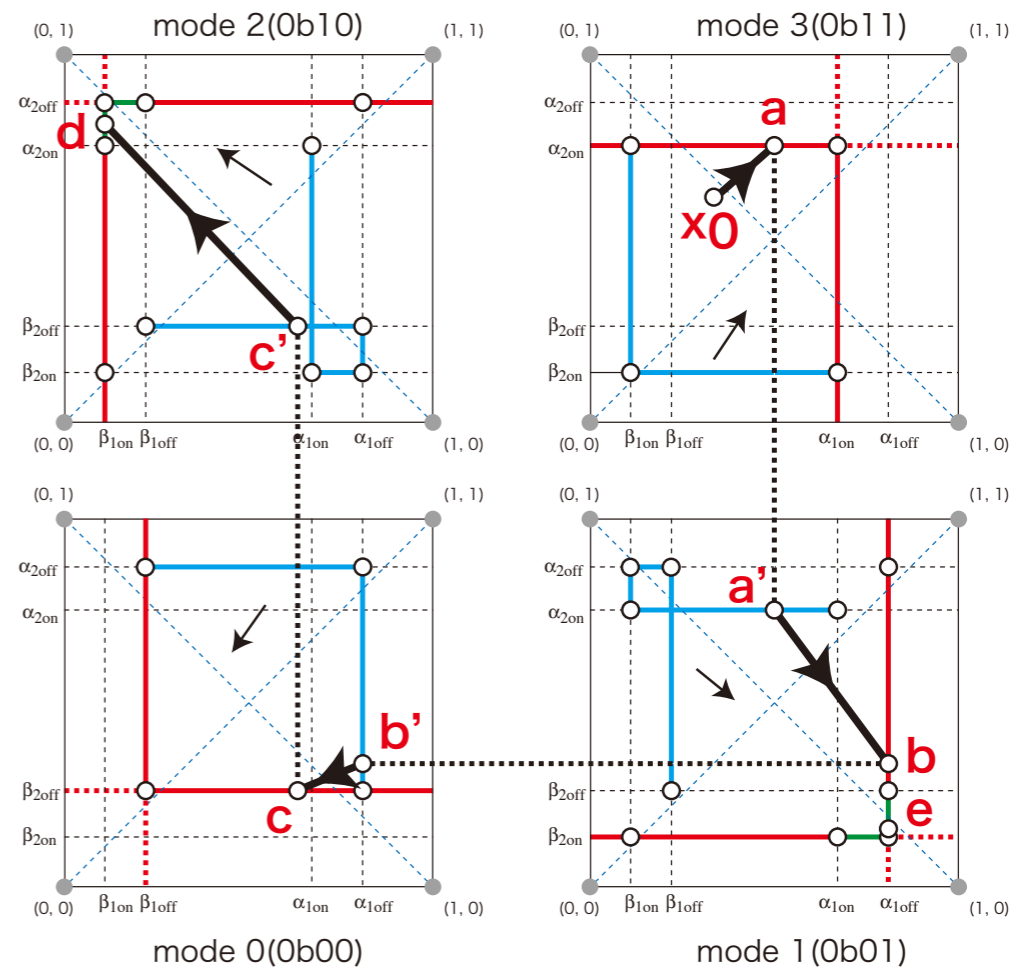


- arrival set
- departure set
- codimension 2 property

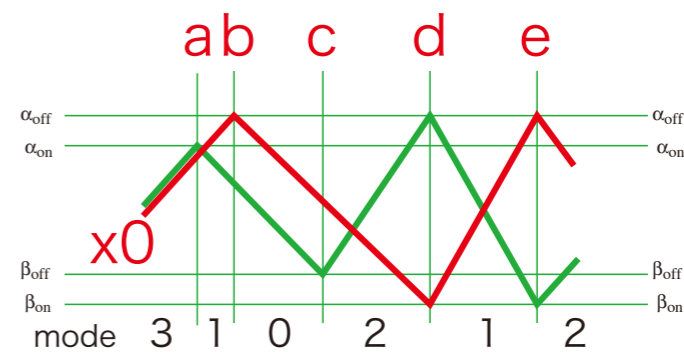
### type C1-C1 circuit : phase portrait

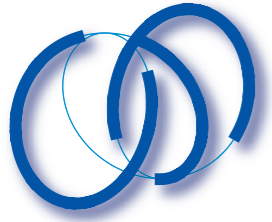


template for vector fields

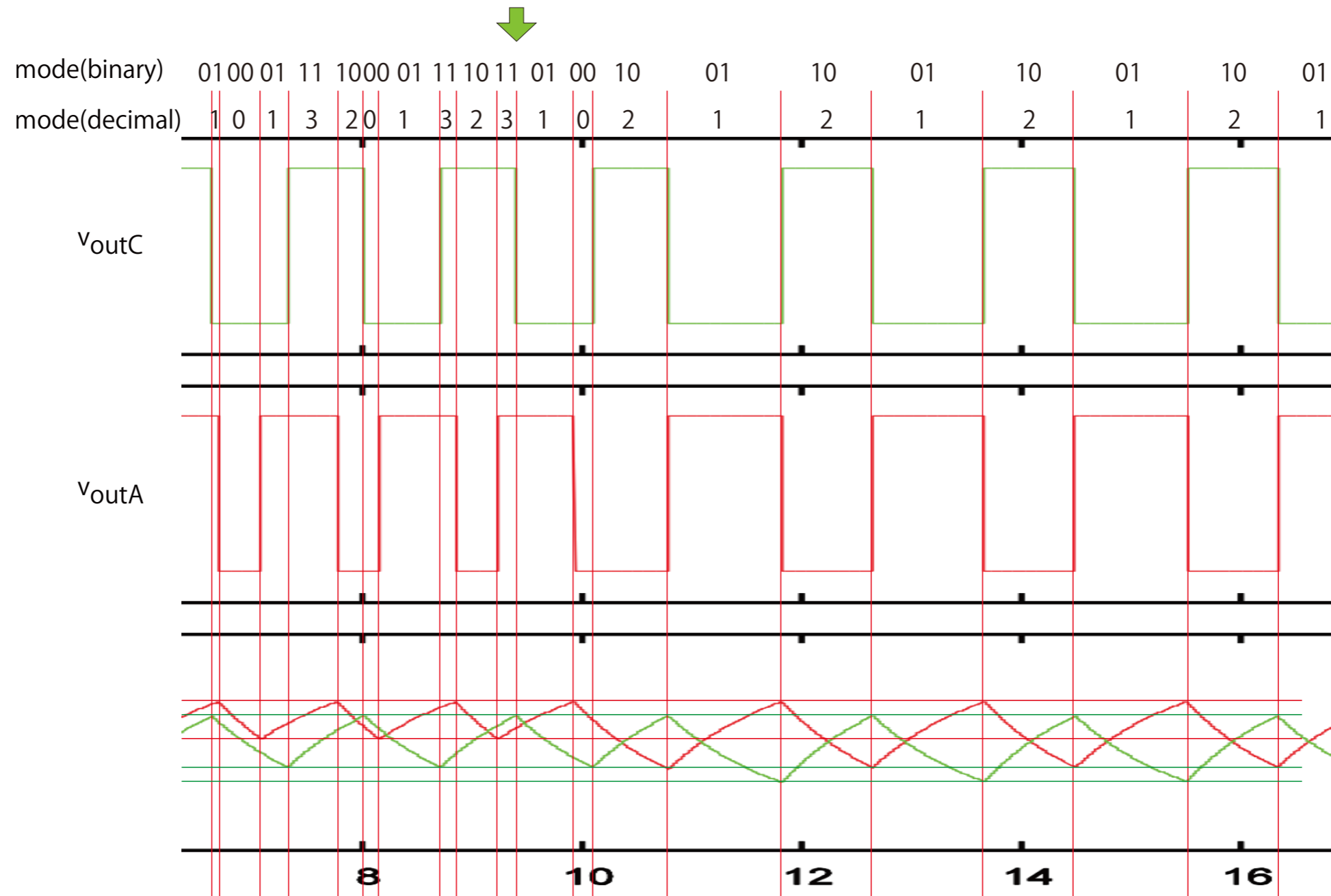


waveforms



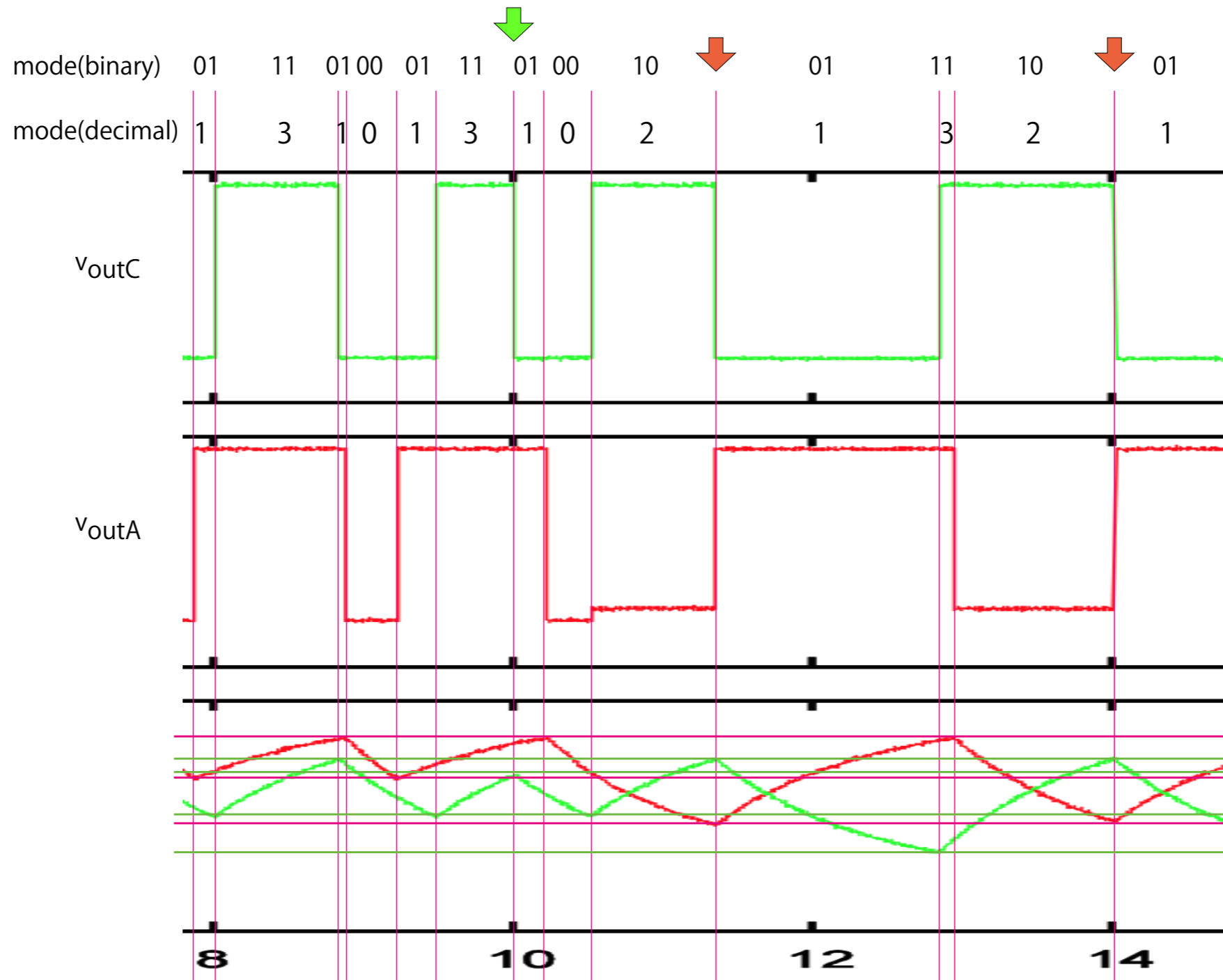


typeA-typeC coupled system(Numerical simulation) p. 22  
in ExperimentalResults\_20120402.pdf

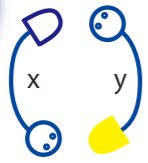
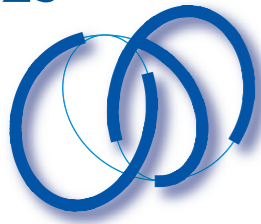




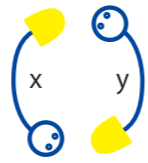
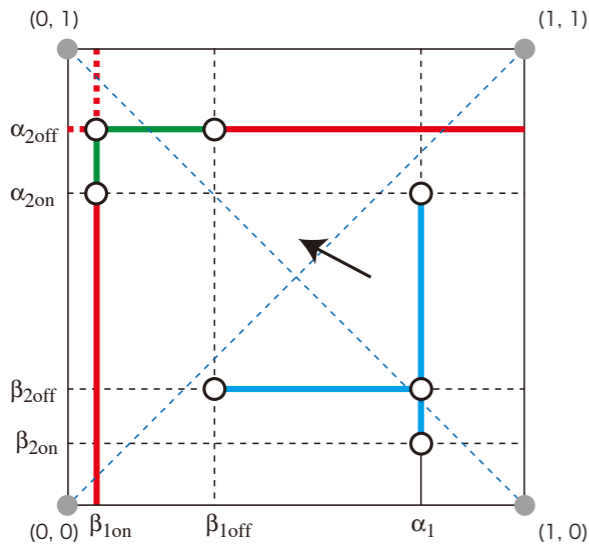
typeA-typeC coupled system(Experimental results) p. 21  
in ExperimentalResults\_20120402.pdf



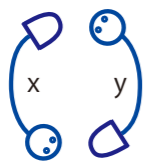
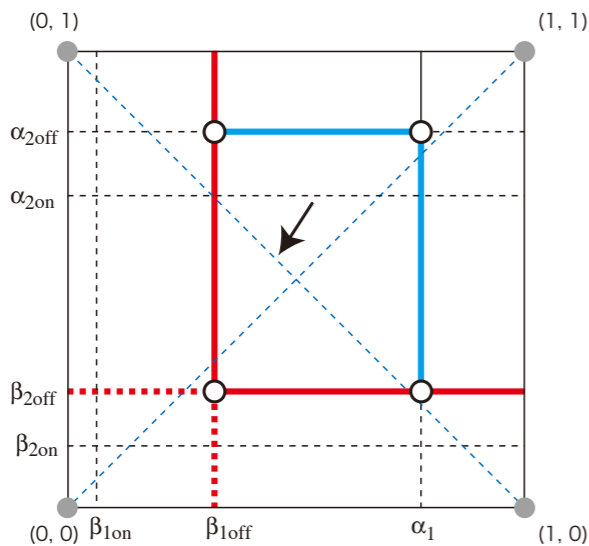
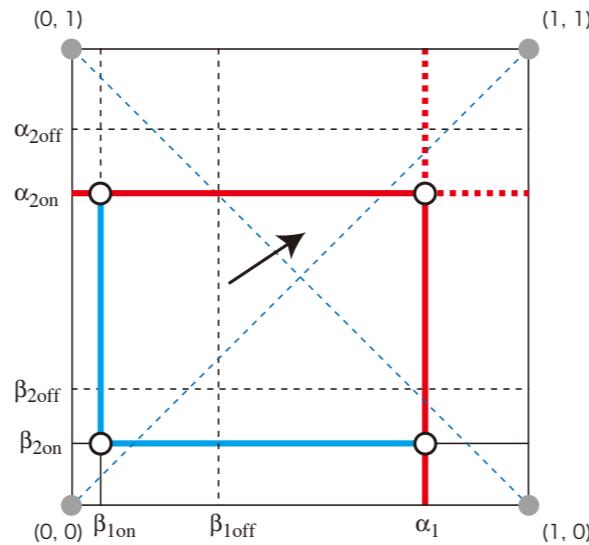
**31021321321...**



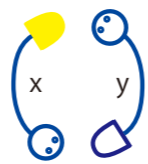
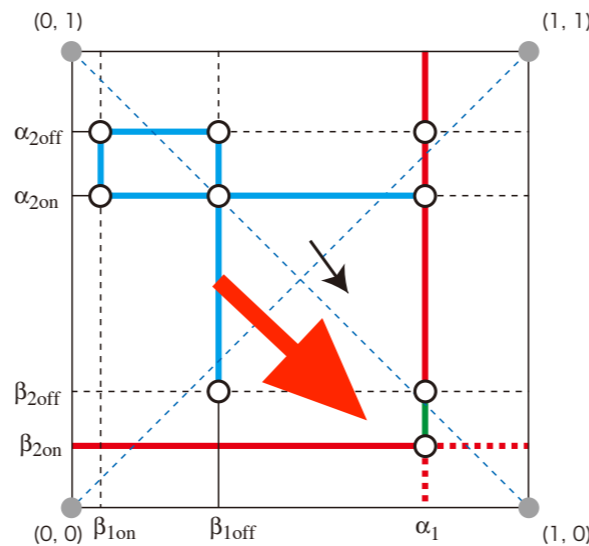
mode 2  
0b10



mode 3  
0b11



mode 0  
0b00



mode 1  
0b01

### type A1-C1 circuit : phase portrait

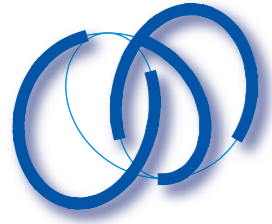
- arrival set
- departure set
- codimension 2 property

- 1) 横軸 x (type A) の閾値  $\alpha_1$  はモード 1, 3 で同じ
- 2) 縦軸 y (type C) の閾値  $\alpha$  はモード 2 で  $\alpha_{2off}$ , モード 3 で  $\alpha_{2on}$  となり, 違った閾値となる.   
これが波形がモード 3 で上の閾値が 1 回小さくなる場合に対応している. experimental results は正常といえる.
- 3) 定常状態では,  $-45deg$  の対角線に漸近する運動となる.   
したがって, 左右両端で codim2 の arrivale set に到達し, 同時切り換えが起こり, 逆相同期解がみられる.
- 4) 関川氏の numerical simulation ではモードの遷移 3 から 1 へのときの  $v$  の閾値が低くなっていない. 回路の抵抗の値を変えて閾値の変化量をうまく選ぶと, 実験データと同じ結果が得られるかも知れない.

**310212121...**

**31021321321...**

**2121...と213213...の違いは？**

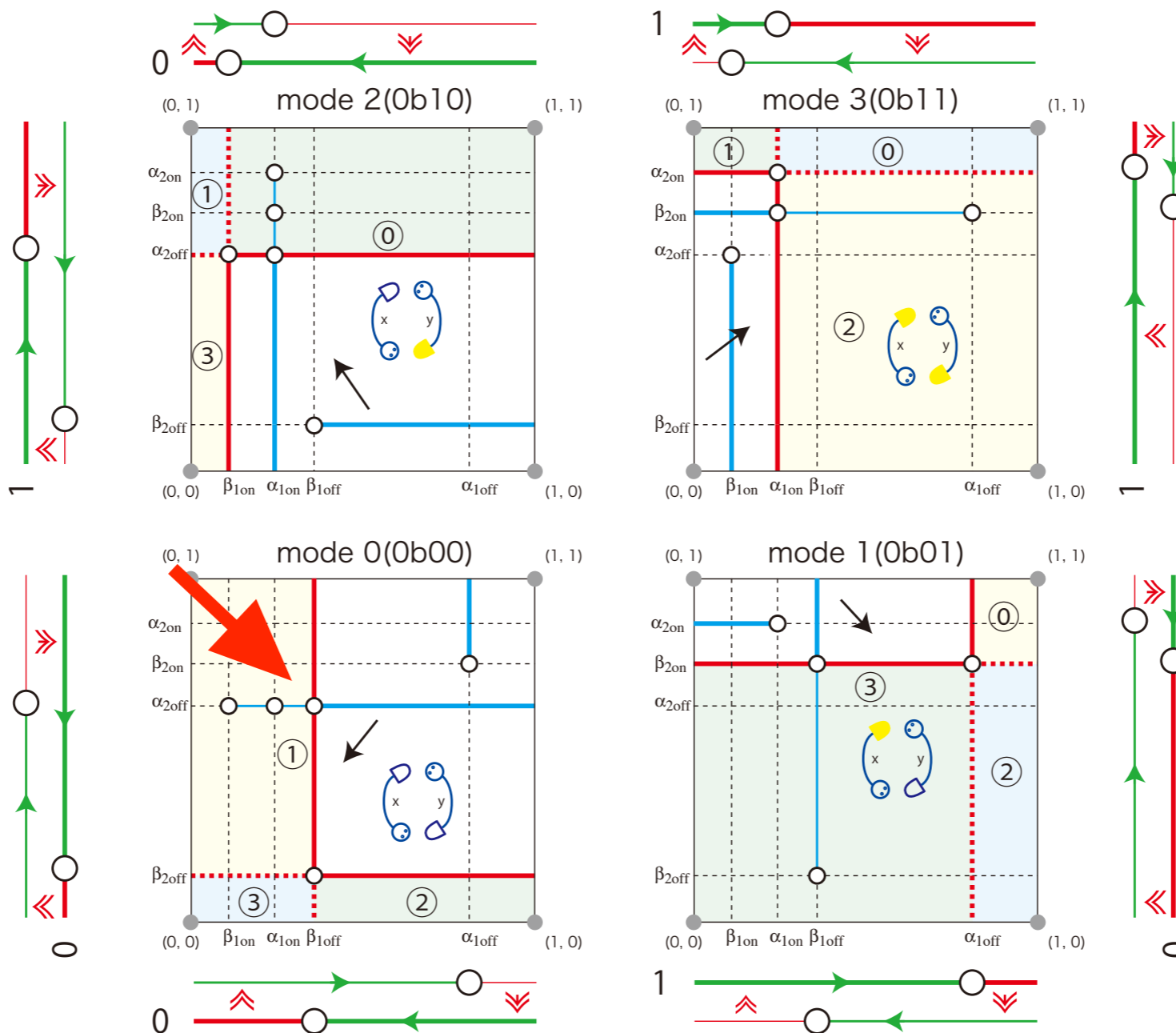


**質問2 : CI-DI 結合では, oscillation deathがおこる.  
なぜ?**





# type C1- D1 circuit : phase portrait

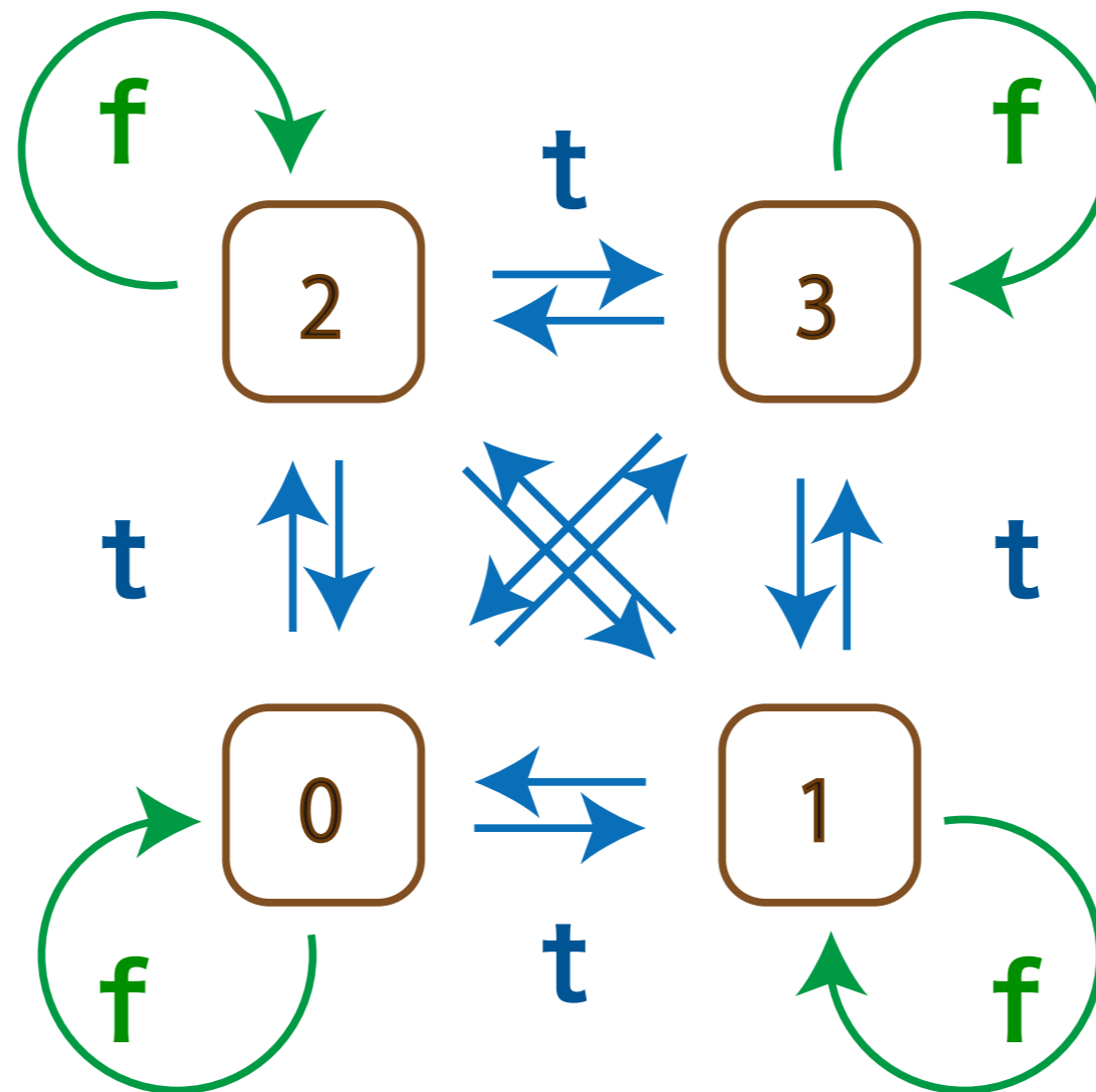


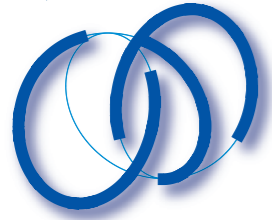
- 1) あるinvariant set 上で transition cycleがおこる.
- 2) このinvariant set はattractiveである.



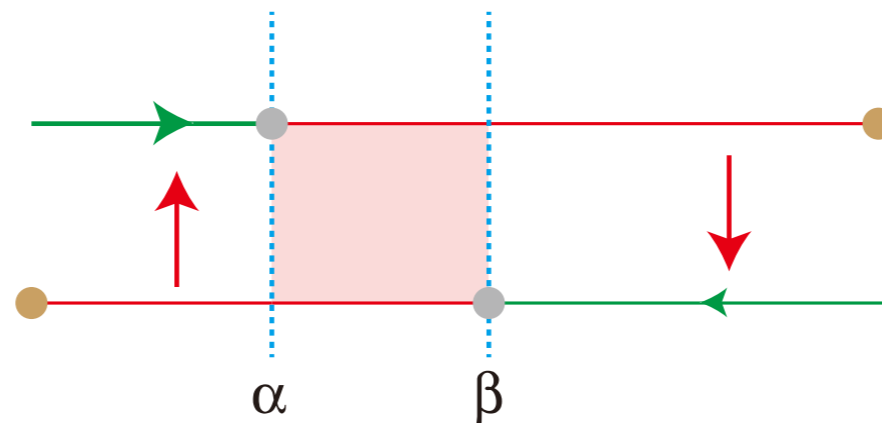
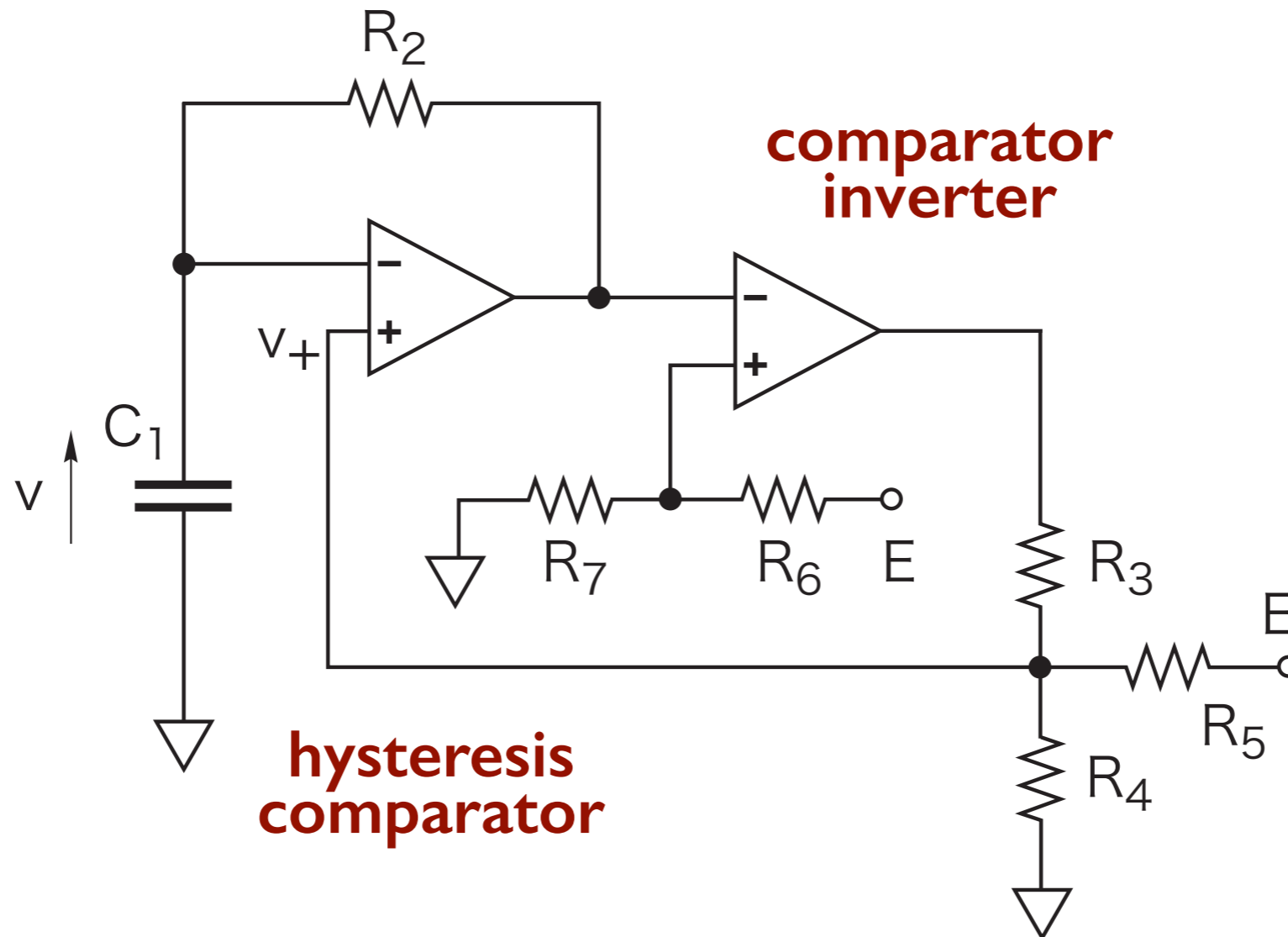
## Hybrid系：状態の進展と遷移

flowが進展している時は、modeは固定されている  
modeが遷移している時は、flowは固定されている



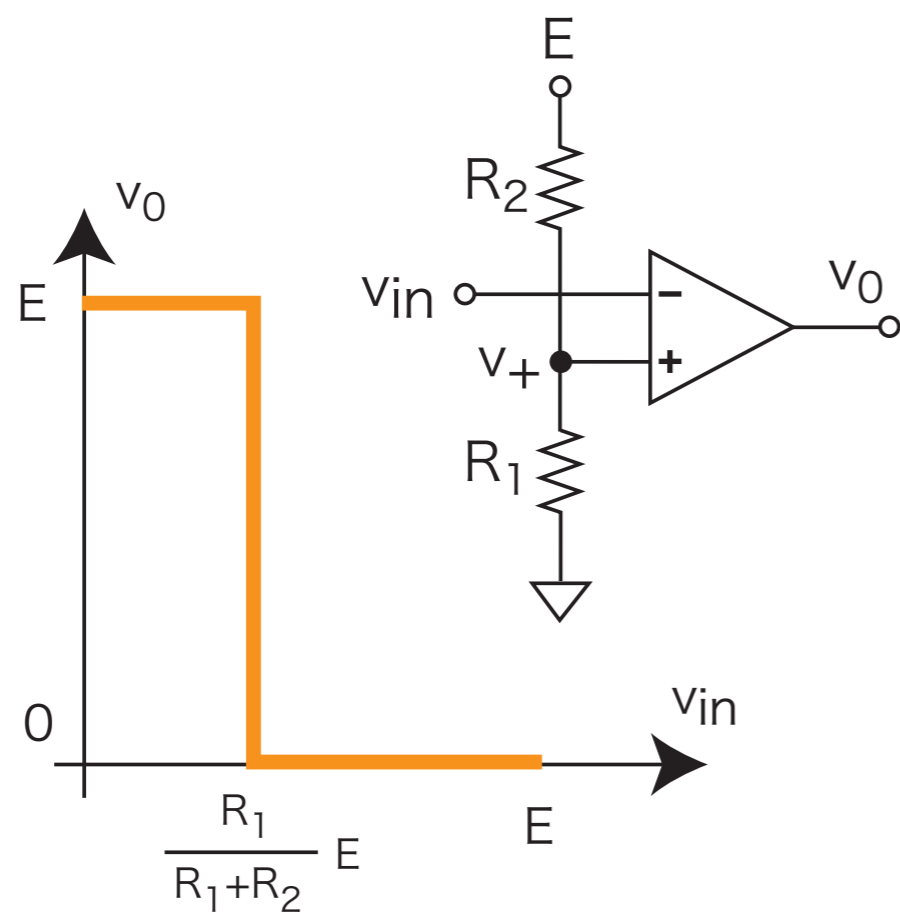


# oscillation death vs transitional oscillation

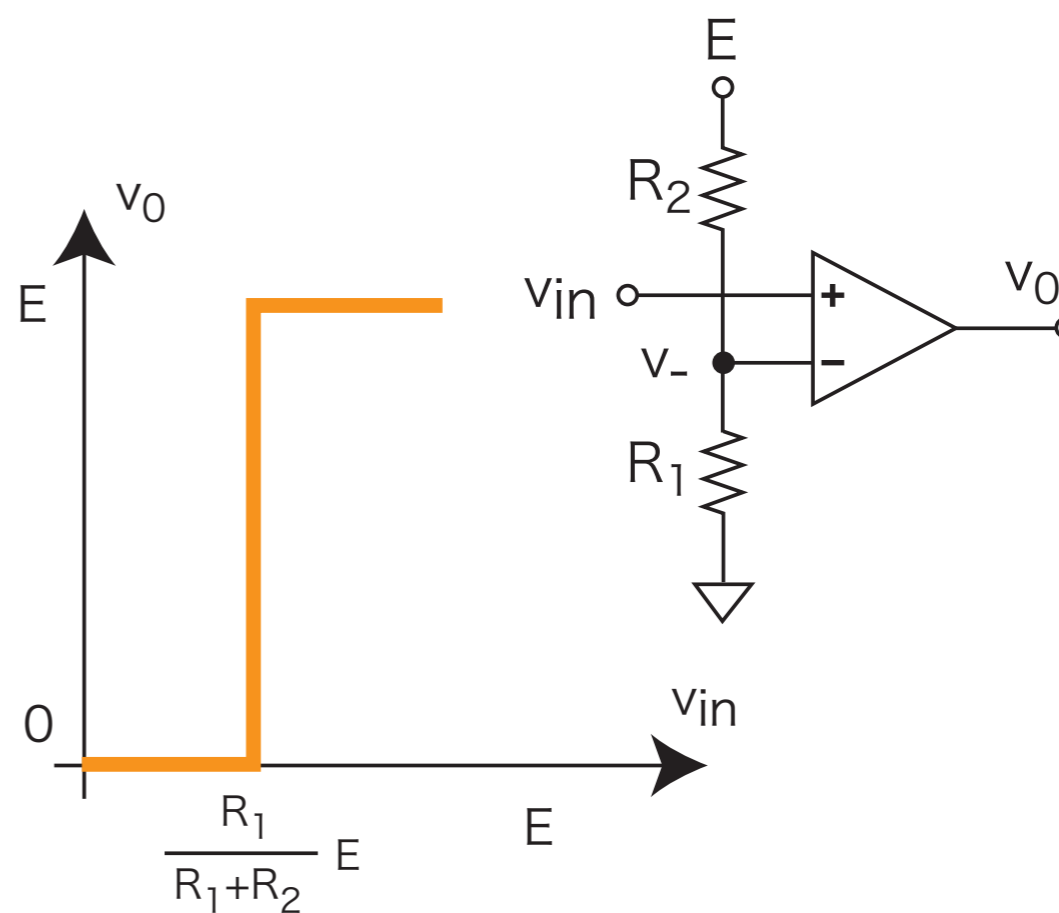




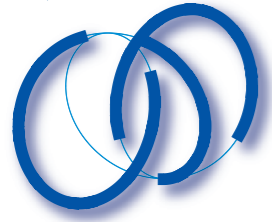
# comparator: Z type vs S type



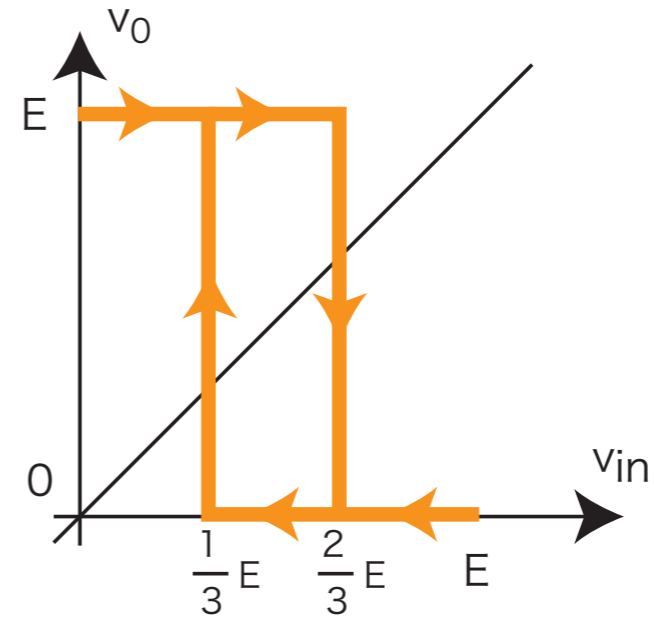
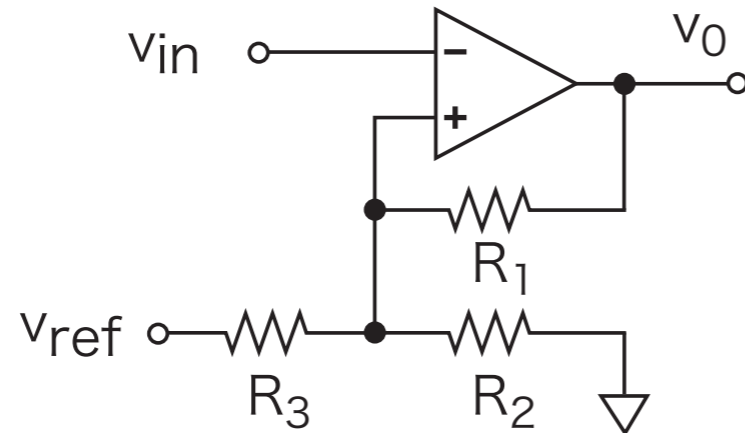
(a)



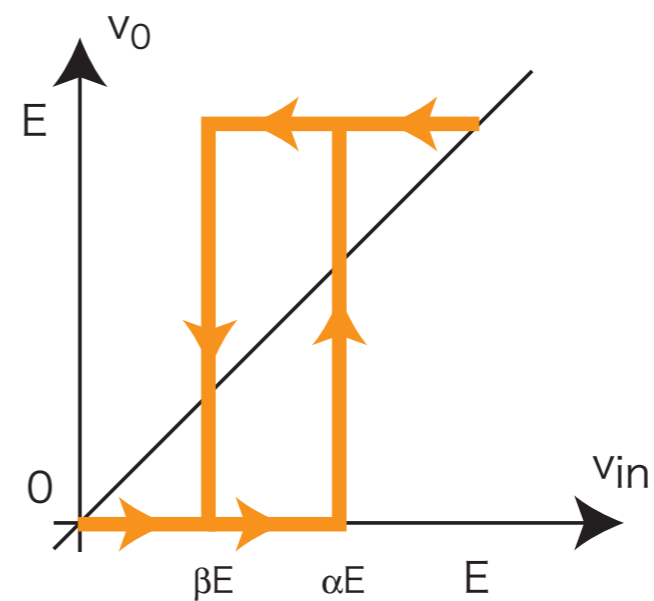
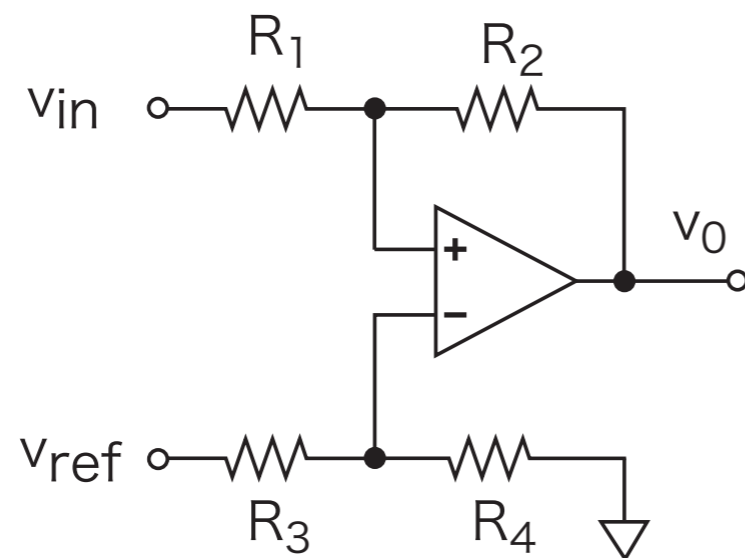
(b)



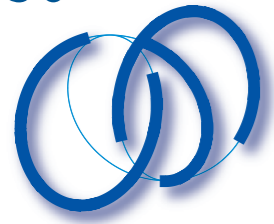
# with hysteresis : Z type vs S type



(a)



(b)



# comparator with hysteresis : S type ?

