



ASEPと一般交通渋滞

- 中央大学理工学部物理学科4年
- 統計物理学・数理物理学研究室
- 大塚 雄之



Thank you for your precious time today.





Jammology

Takeshi Otsuka

Katori Laboratory of Statistics,
Department of Physics,
Faculty of Engineering and Science,
Chuo University

Jammology

jam

→ traffic jam, congestion

-logy

→ denoting a subject
of study or interest

postfix

e.g.) Atomology, Biology, Ecology
Geology, Japanology, Zoology, etc.

Outline

- 1 Introduction
 - Definition of traffic jam

- 2 Explanation of Computer programming
 - ASEP
 - Inertia breaking
 - Chasing
 - Slow start

- 3 Result of each Computer programming

- 4 Actual traffic jam
 - Transportation Demand Management
 - Enhancement of Traffic Management

- 5 Summary

1 Introduction

Definition of “jam”...

According to the dictionary

➡ jam ; an instance of a thing seizing or becoming stuck

Oxford Dictionary of ENGLISH (C)Oxford University Press 2003

new year's visit to a shrine
/new year's praying



Hakone Ekiden event



According to the JARTIC and NEXCO

Definition of “jam”

Tokyo Metropolitan Expressway
Hanshin Expressway etc.

So-called “渋滞”

| | Expressway | Urban Expressway | General road |
|---------|------------------|------------------|------------------|
| jam | Less than 40km/h | Less than 20km/h | Less than 10km/h |
| crowded | | 20 ~ 40km/h | 10 ~ 20km/h |

What we call “混雑”



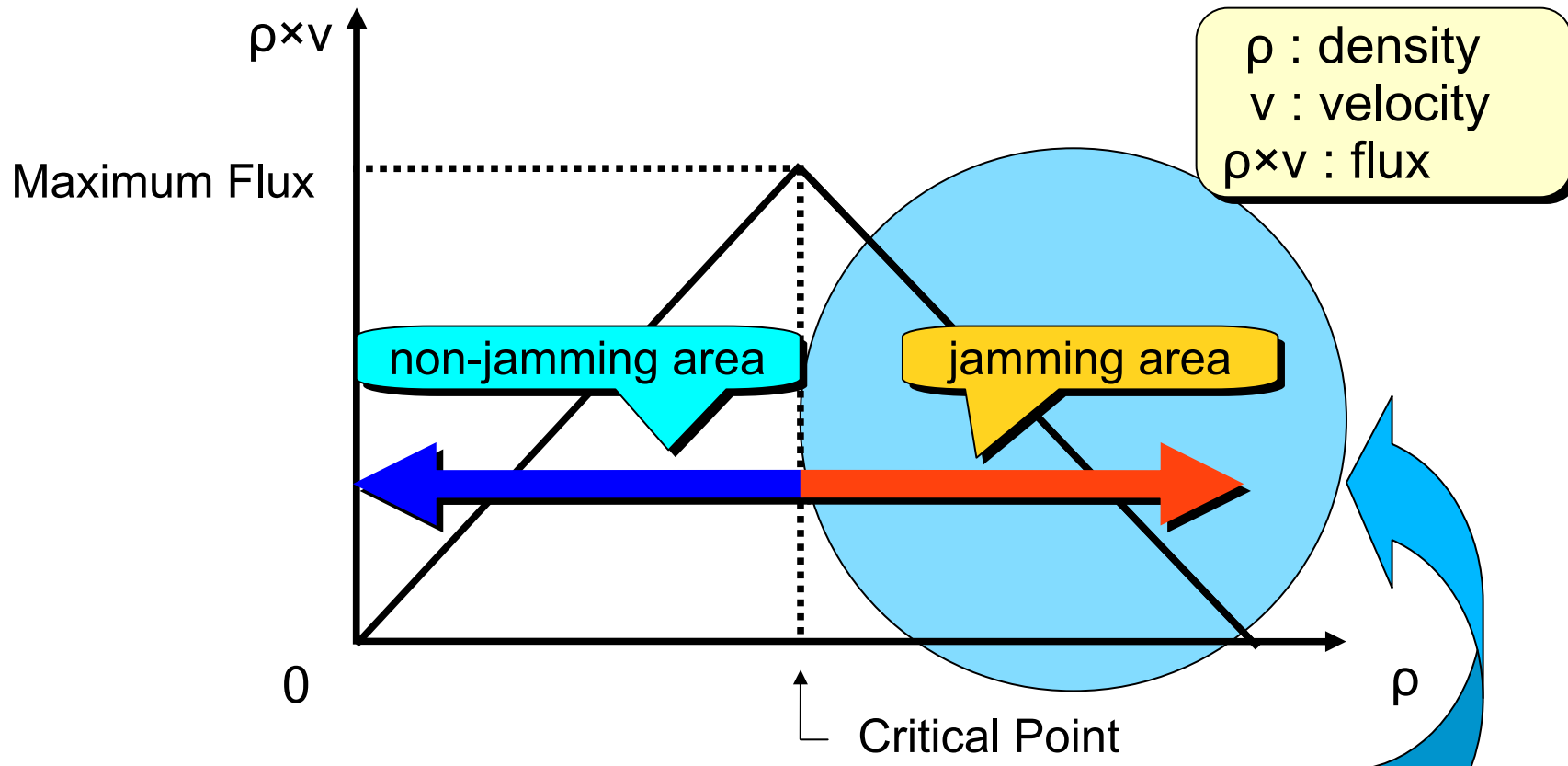
By the way...

NEXCO ; Nippon Expressway
Company Limited

JARTIC ; Japan Road Traffic
Information Center

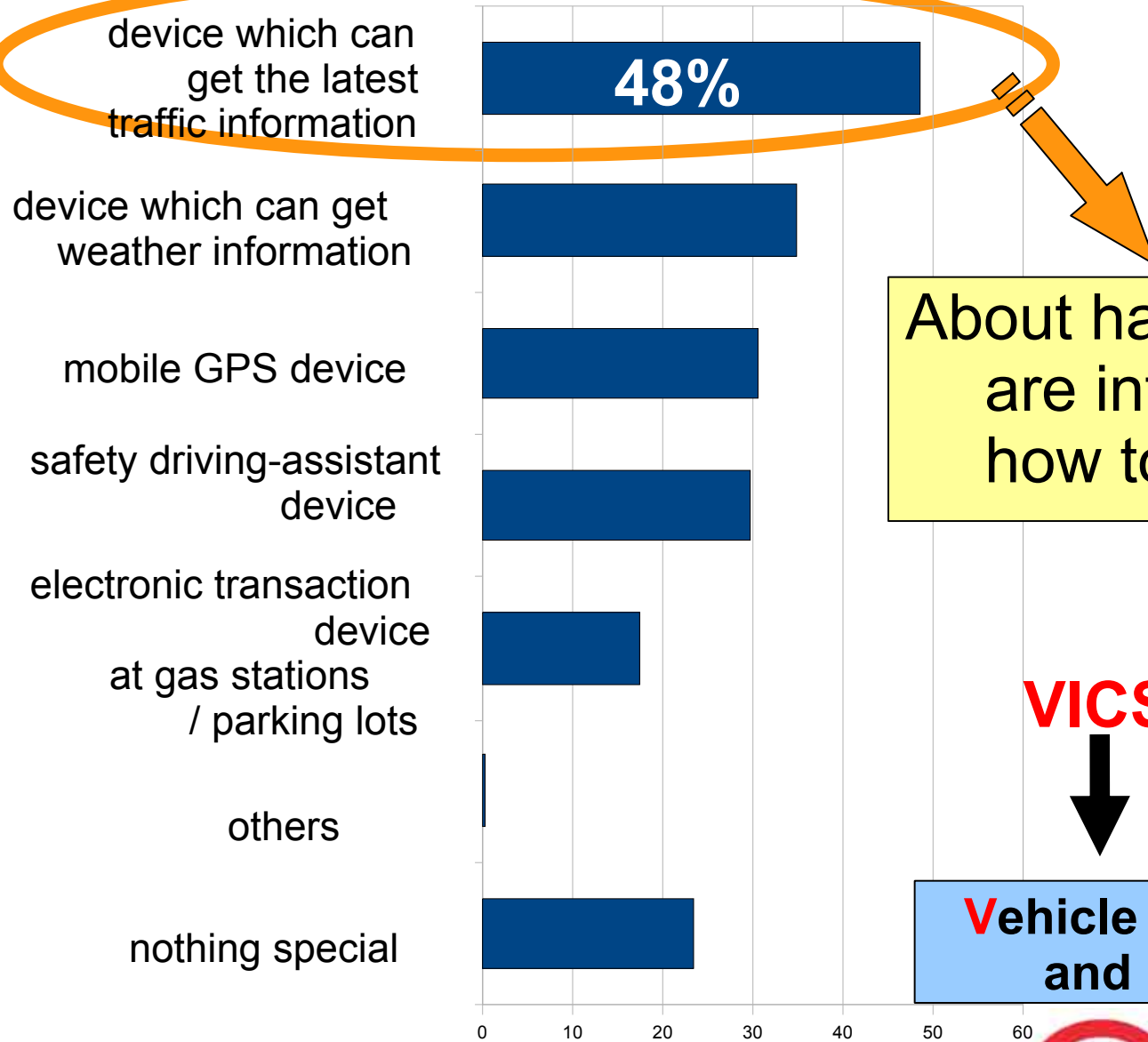
In jammological field...

Fundamental diagram of ASEP



jam : the value of density is higher than the value of critical point

Intelligent Transport System which people want to use



About half number of people are interested in how to avoid traffic jams!

VICS
↓

Vehicle Information and Communication System

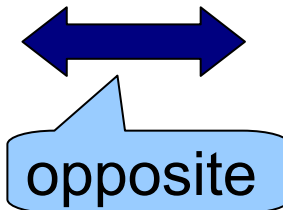
2 Explanation of programming

ASEP → **A**symmetric **S**imple **E**xclusion **P**rocess

stand for...

- **A**symmetric ; having two sides or parts that are not the same in size or shape

e.g.) asymmetric hair style (what we call “アシメ”)

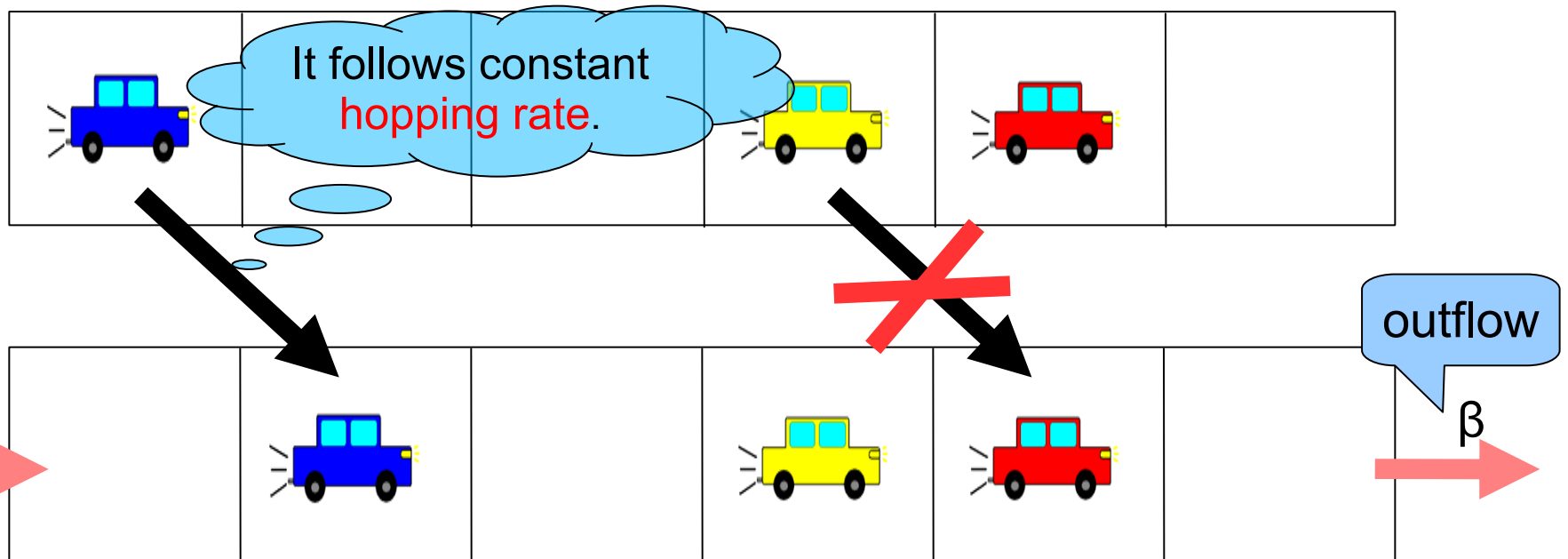


symmetric
hair style

- Exclusion ; exclusion effect

Two particles or more can't occupy the same site.

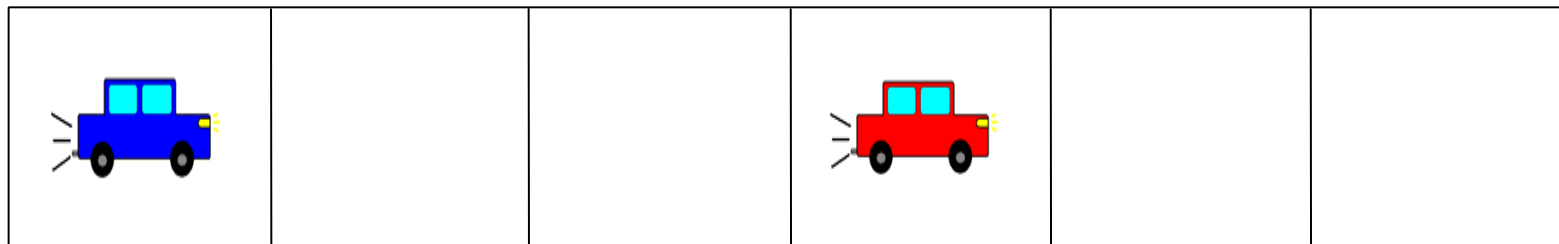
e.g.)



Explanation of "hopping rate"

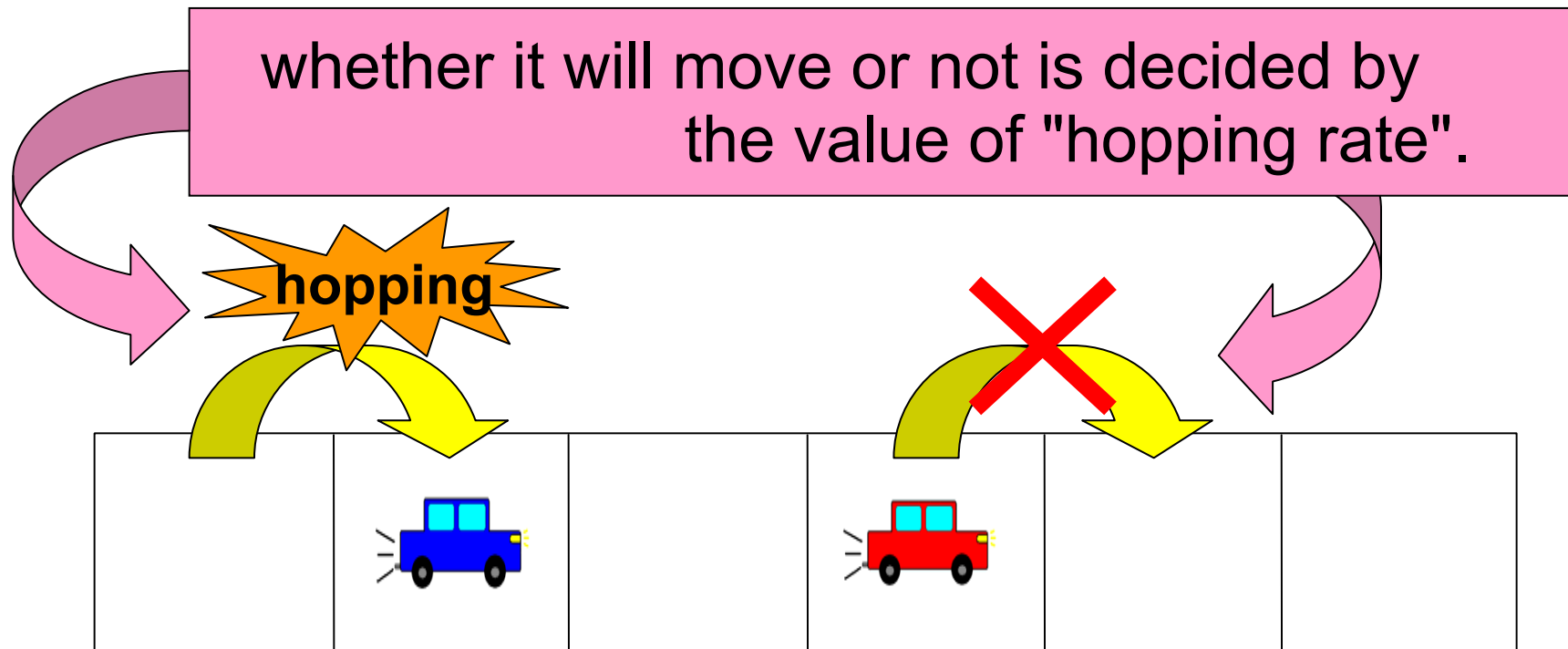
 Rate that particle actually hops that is in state that can be hopped in particle

whether it will move or not is decided by the value of "hopping rate".

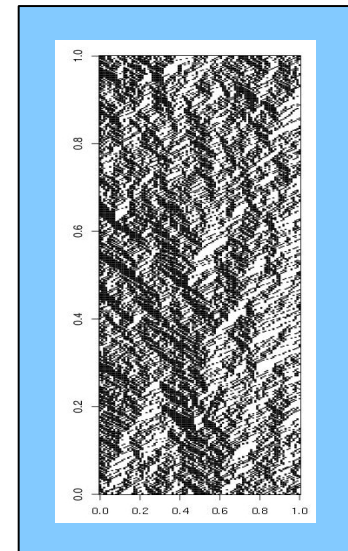
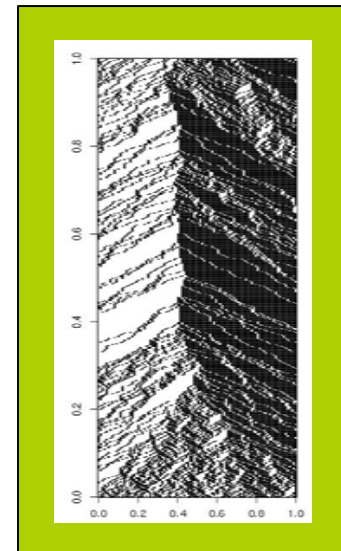
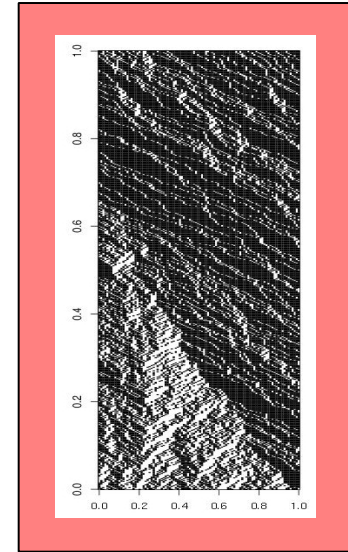
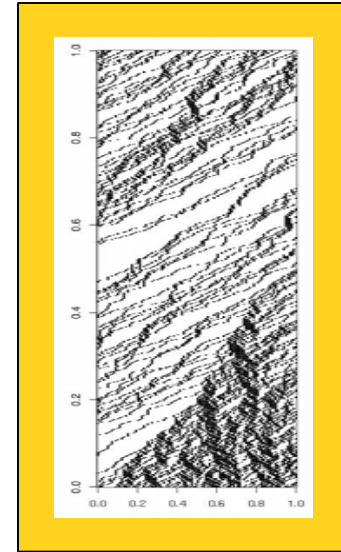
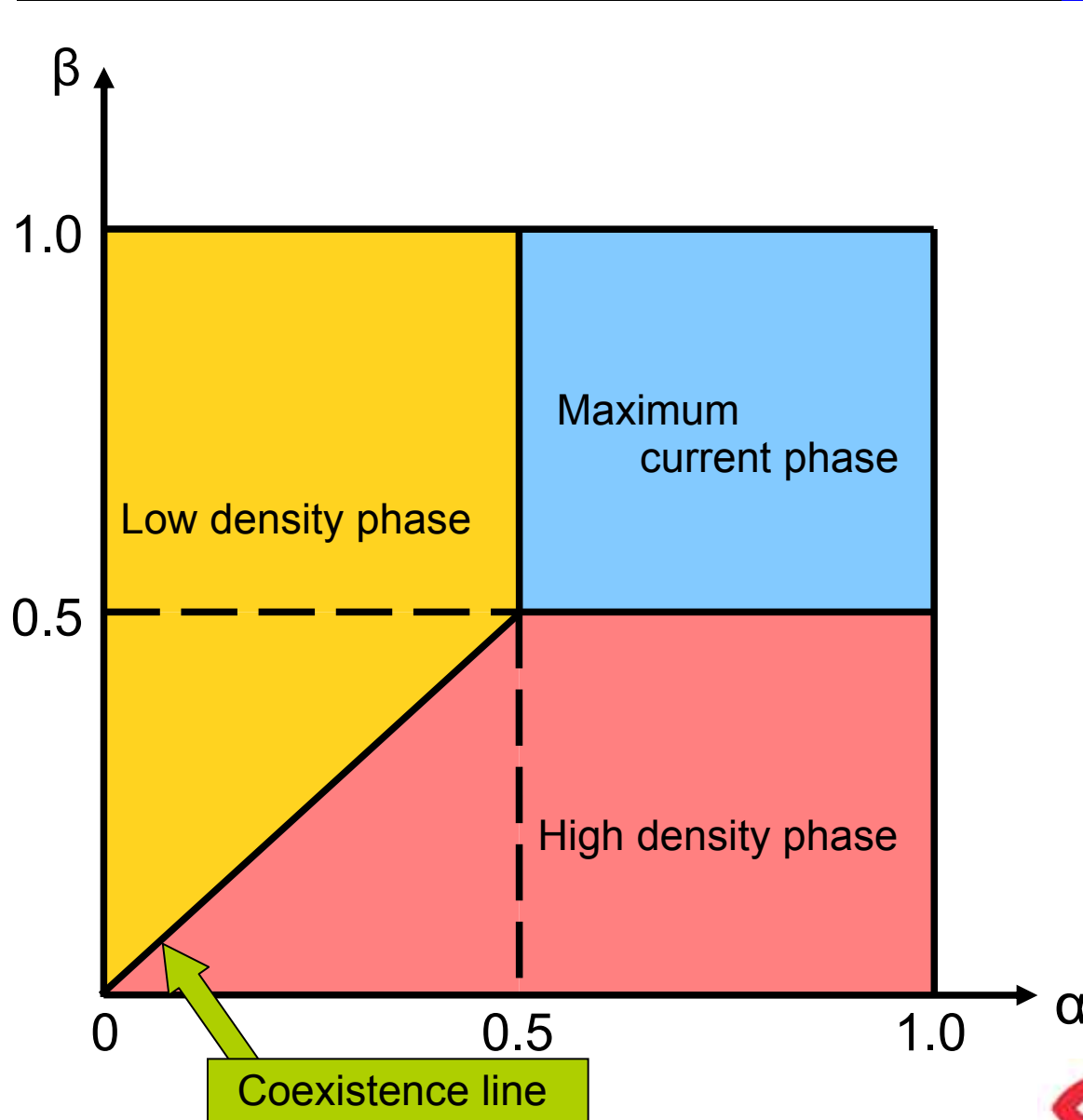


Explanation of "hopping rate"

➡ Rate that particle actually hops that is in state that can be hopped in particle

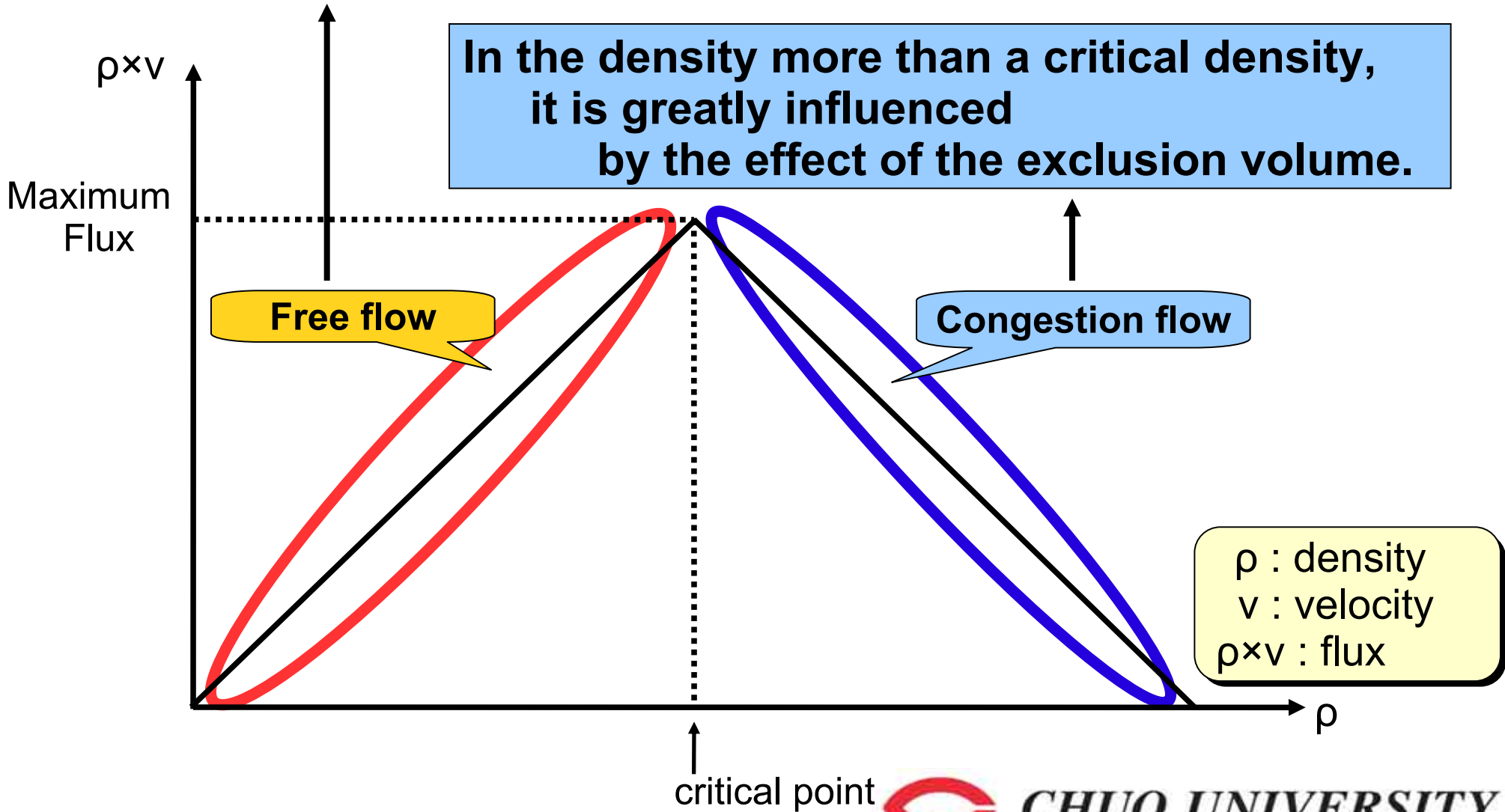


Four characteristics by value of α and β ...



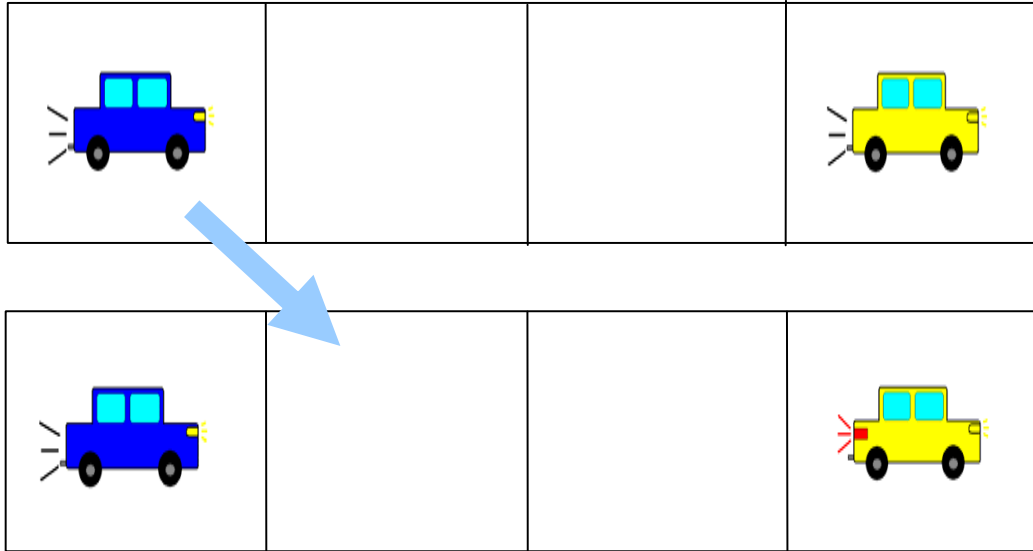
In the density below a critical density,
it is not restrained so much in the exclusion volume.

In the density more than a critical density,
it is greatly influenced
by the effect of the exclusion volume.



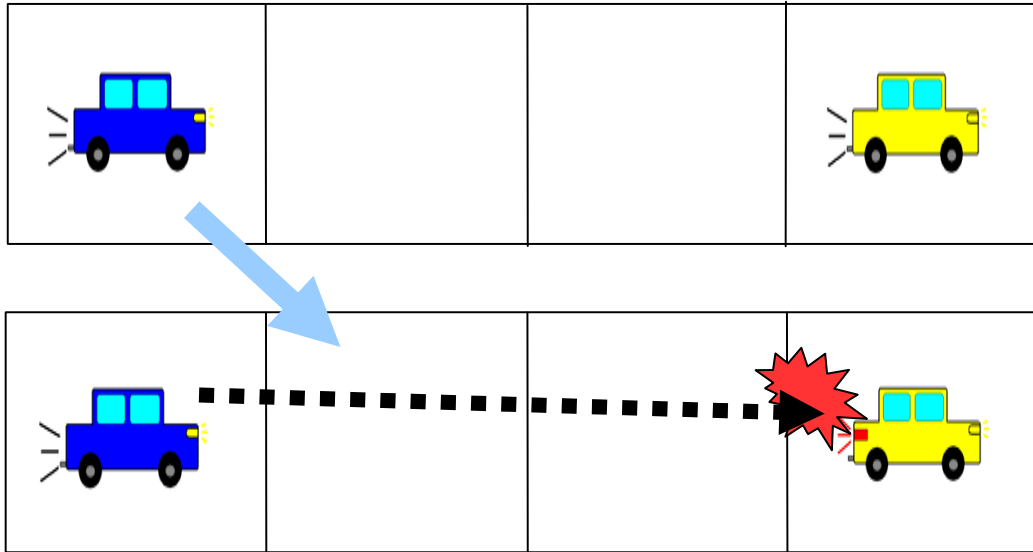
- Inertia breaking

; We tend to step on the brake when we see taillights of the car in front in order to keep the distance between two cars.



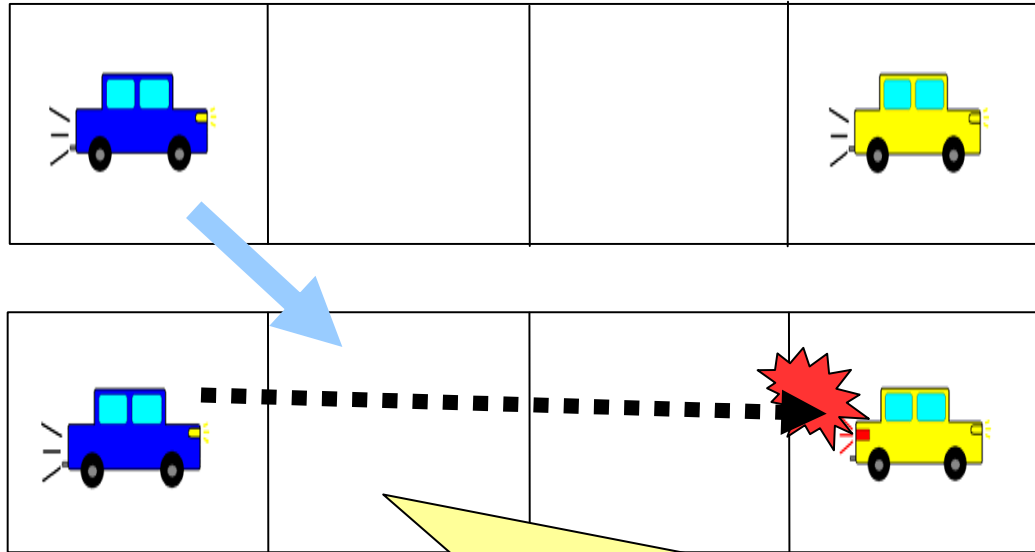
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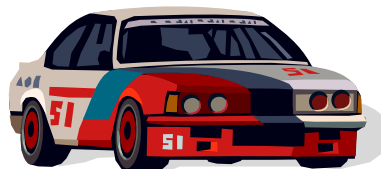
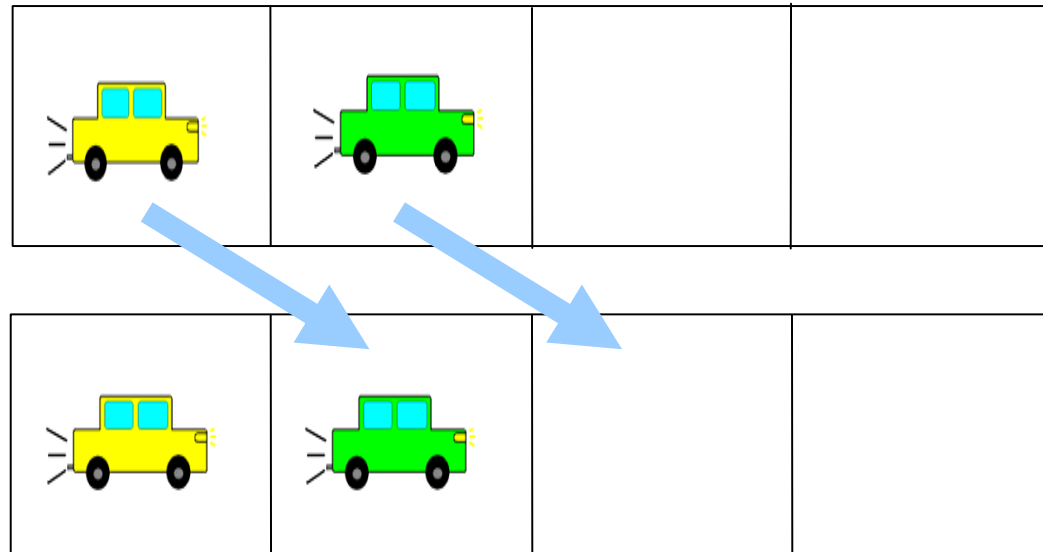


As a result, the car decelerates!

Lower the value of hopping rate

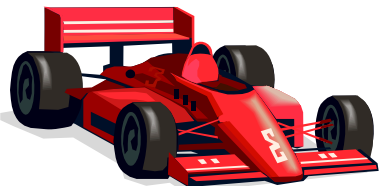
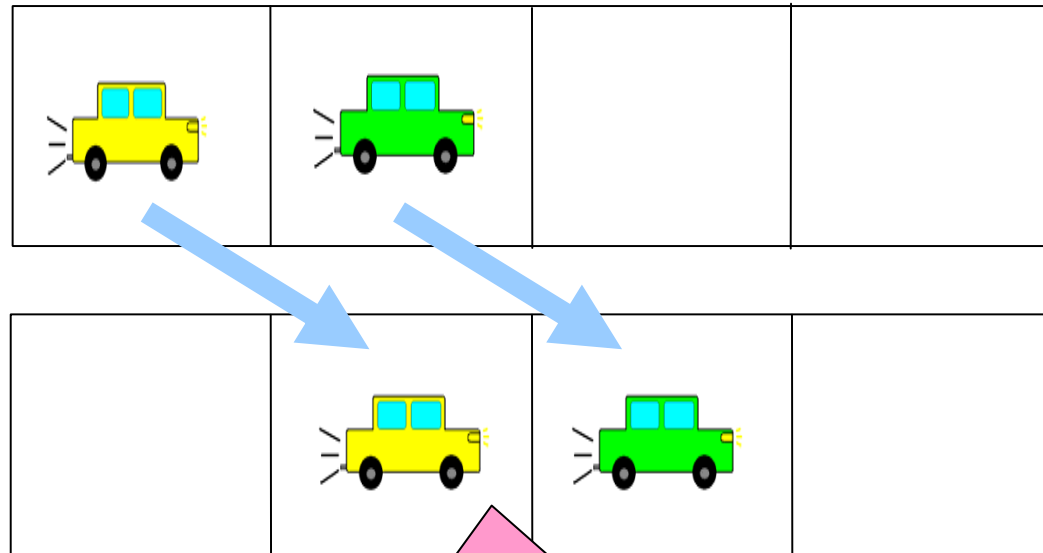
- Chasing

; The car begin to move with the car that exists ahead.



- Chasing

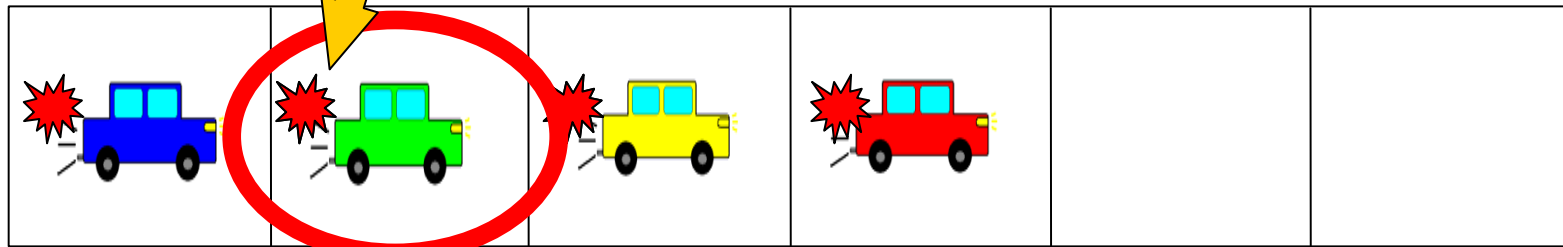
; The car begin to move
with the car that exists ahead.



They moves as if one car.

- slow start

The car that stops once can't move easily.



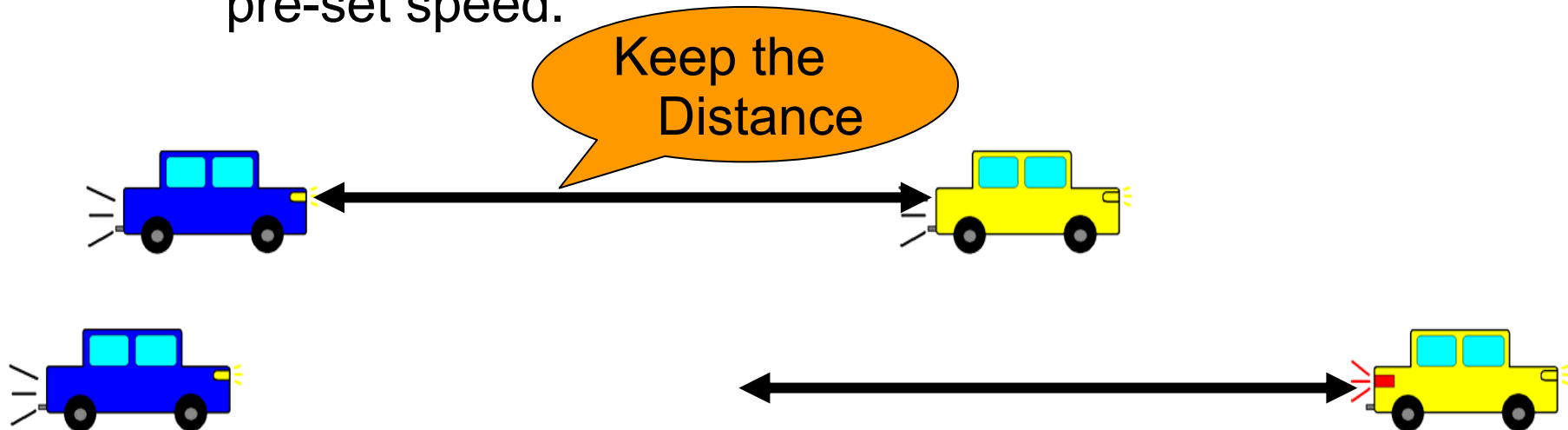
It is not possible
to start at once.



Latest technology...

- Intelligent cruise control system

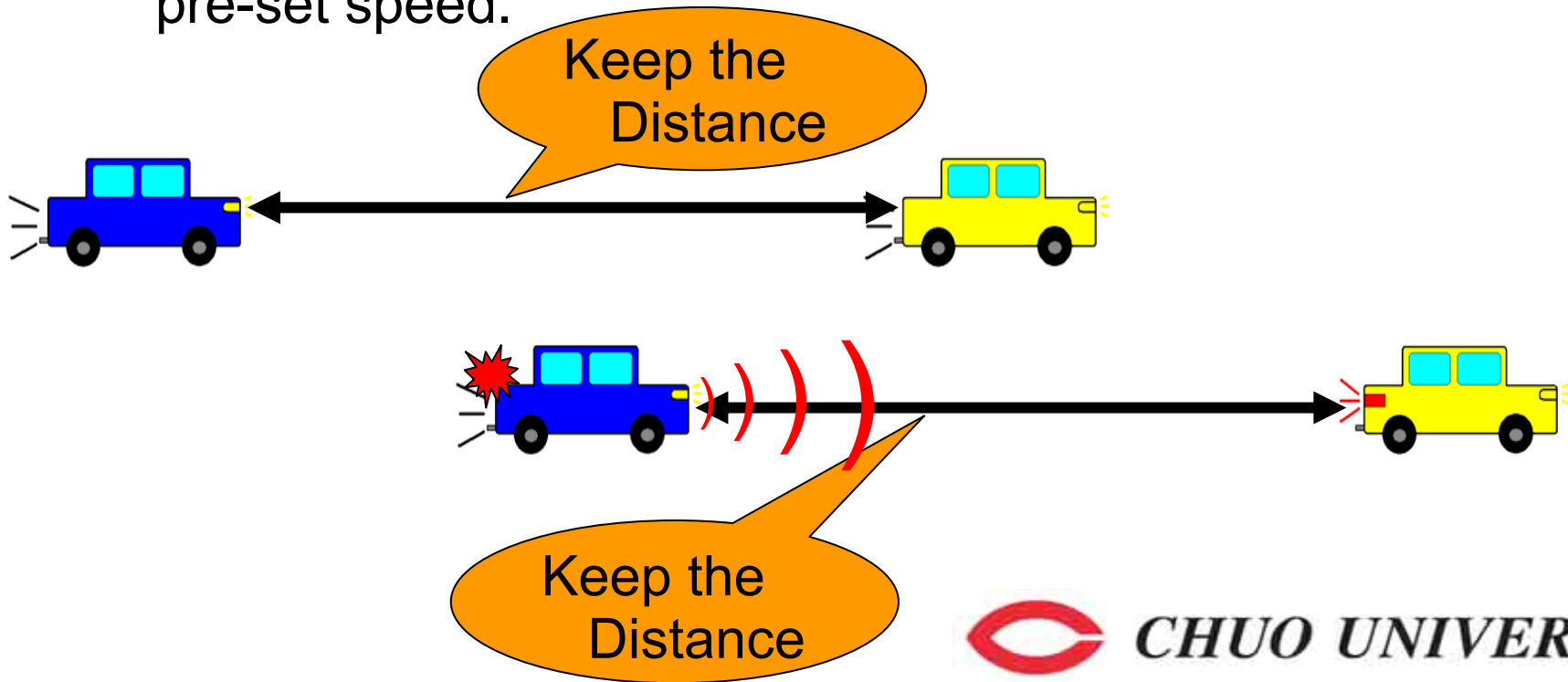
The radar help to maintain a pre-set following distance. Should the vehicle get too close to the vehicle ahead, the throttle is automatically reduced and the brakes are applied. As soon as the road ahead clears, the vehicle returns to its pre-set speed.



Latest technology...

- Intelligent cruise control system

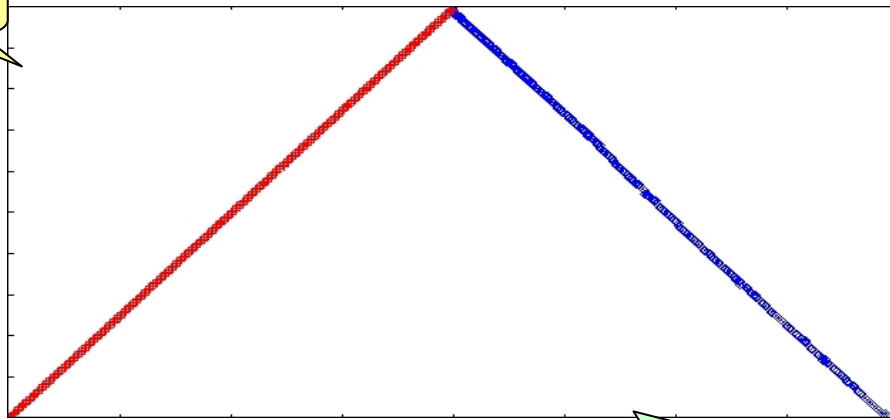
The radar help to maintain a pre-set following distance. Should the vehicle get too close to the vehicle ahead, the throttle is automatically reduced and the brakes are applied. As soon as the road ahead clears, the vehicle returns to its pre-set speed.



3 Result of each Computer programming

Simple ASEP

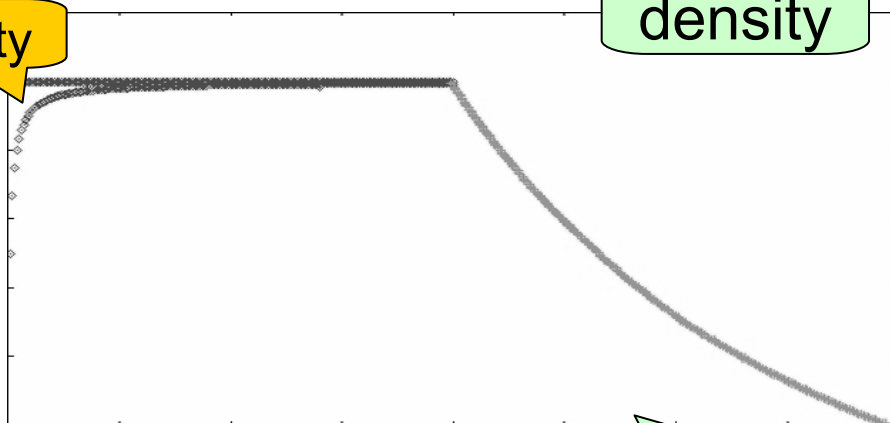
flux



Fundamental diagram

Graph of relation between ρ and $(\rho \times v)$

velocity



density

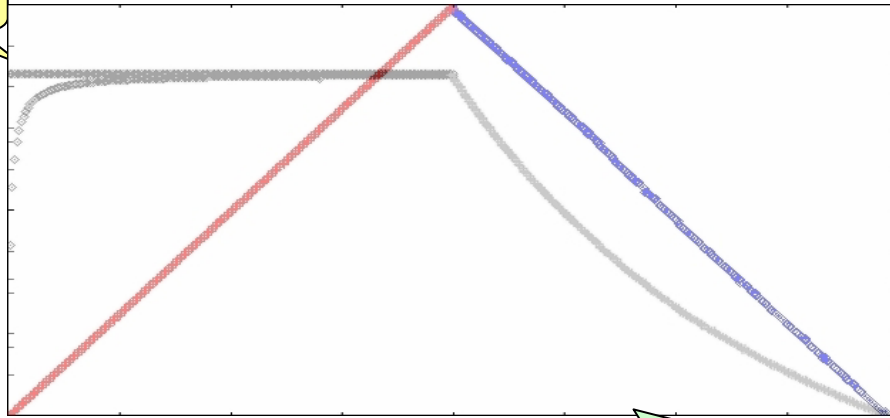
Graph of relation between v and ρ

density

3 Result of each Computer programming

Simple ASEP

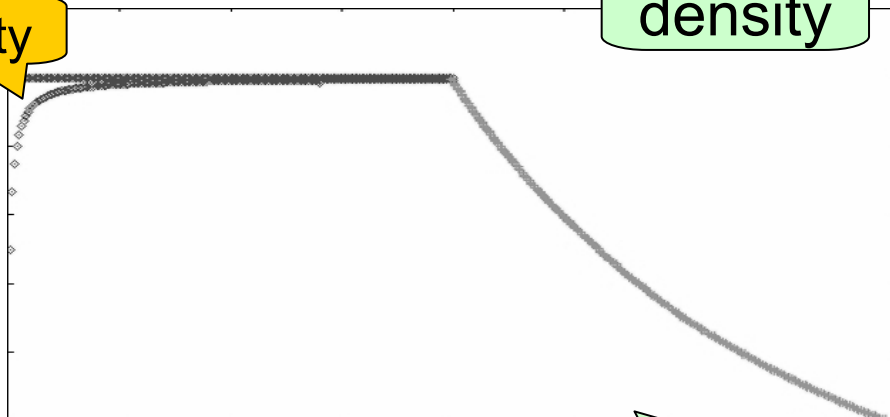
flux



Fundamental diagram

Graph of relation between ρ and $(\rho \times v)$

velocity



density

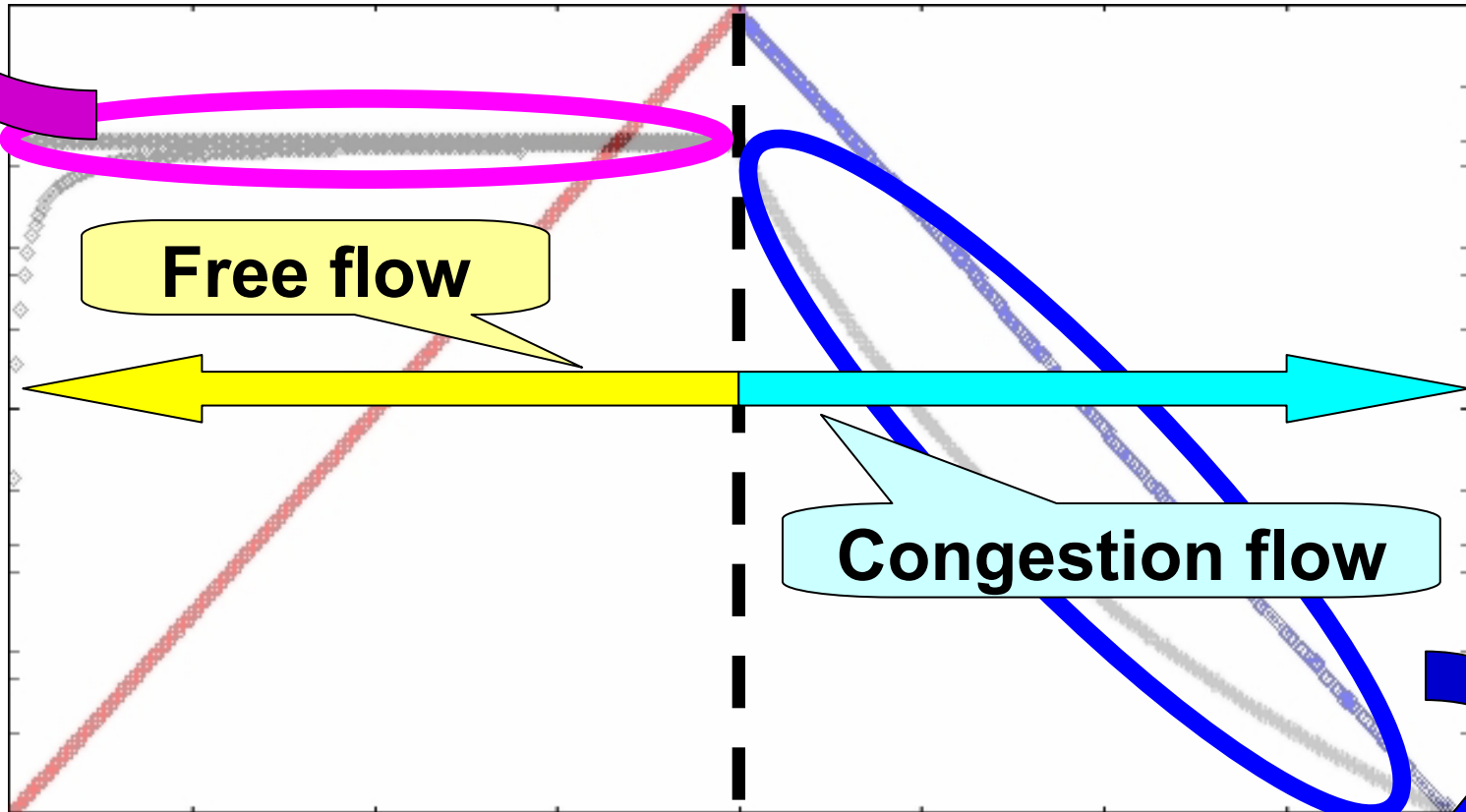
Graph of relation between v and ρ

density

The value of v almost becomes constant, because the effect of the exclusion volume hardly influences it in Free flow.

$v /$

$x v$

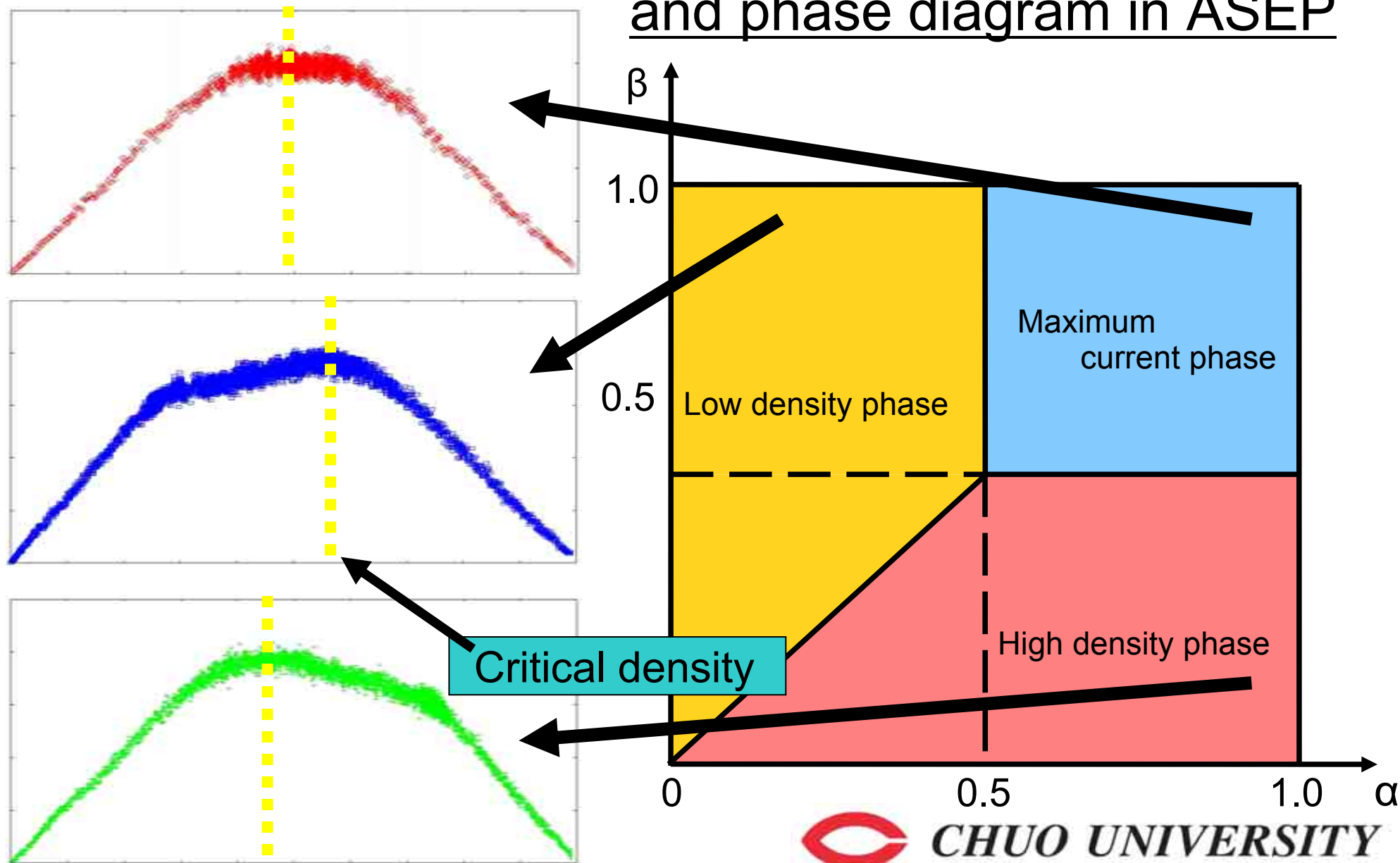


Free flow

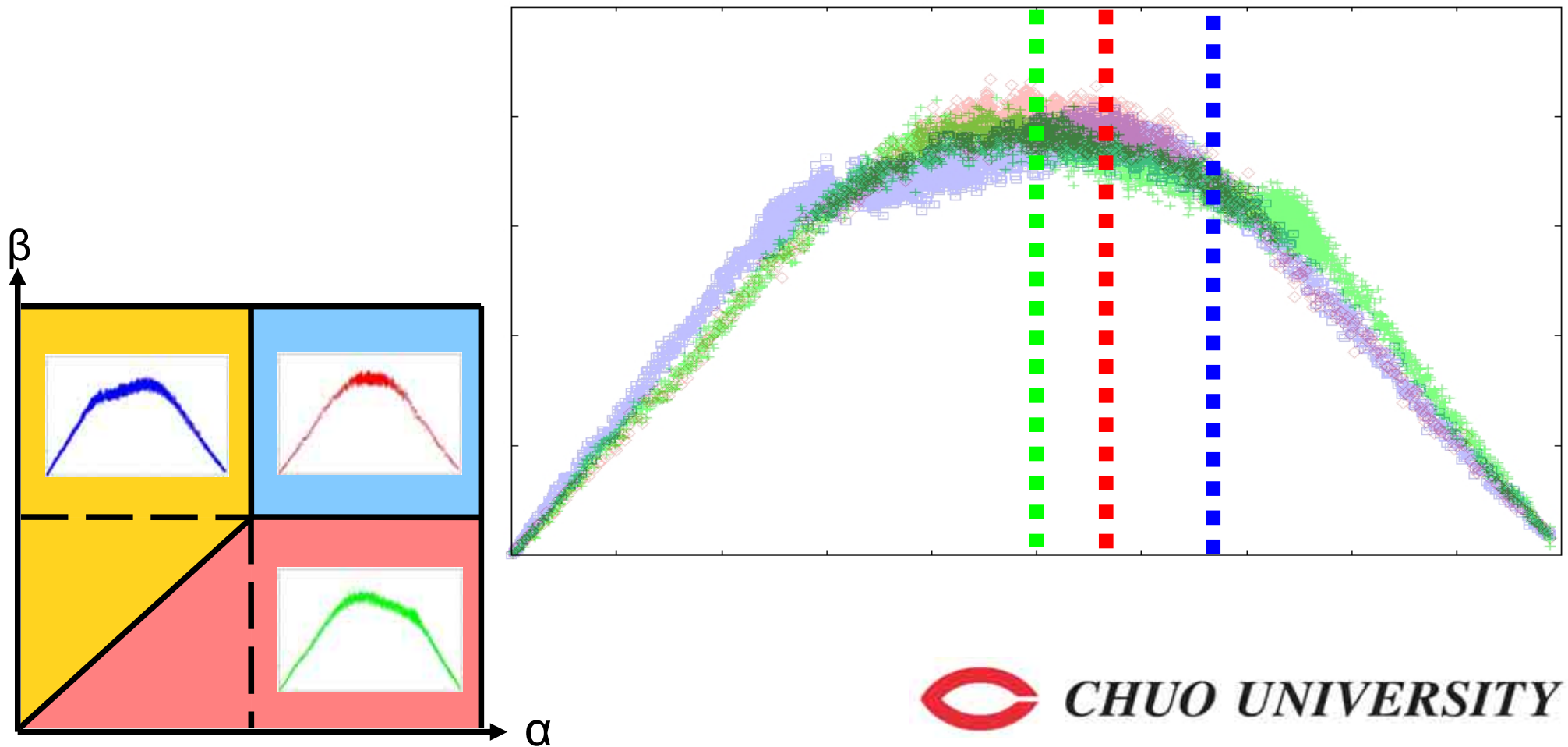
Congestion flow

The value of v decreases in the quadratic function by the effect of the exclusion volume in the area of Congestion flow.

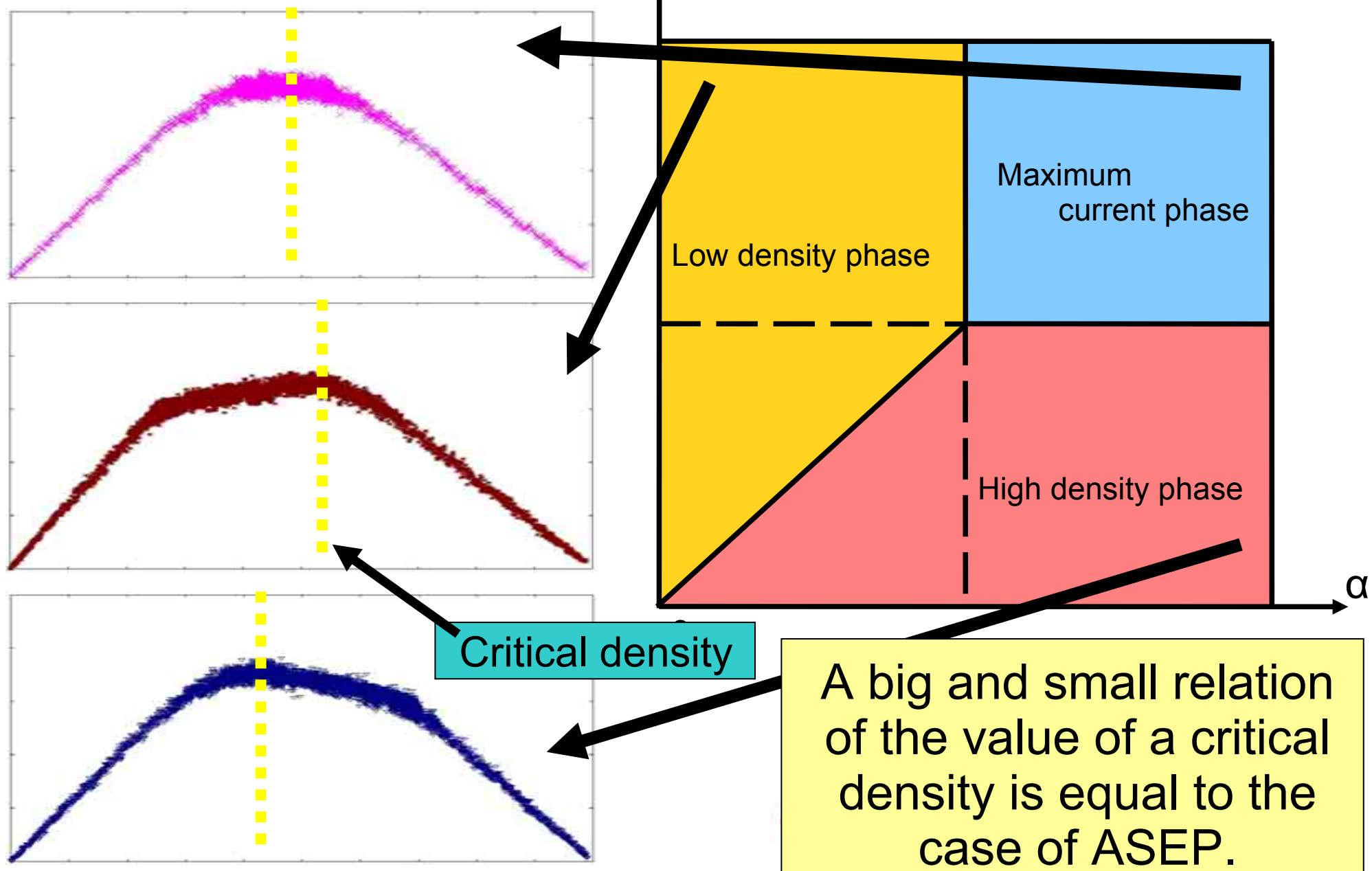
Relation between Fundamental diagram and phase diagram in ASEP



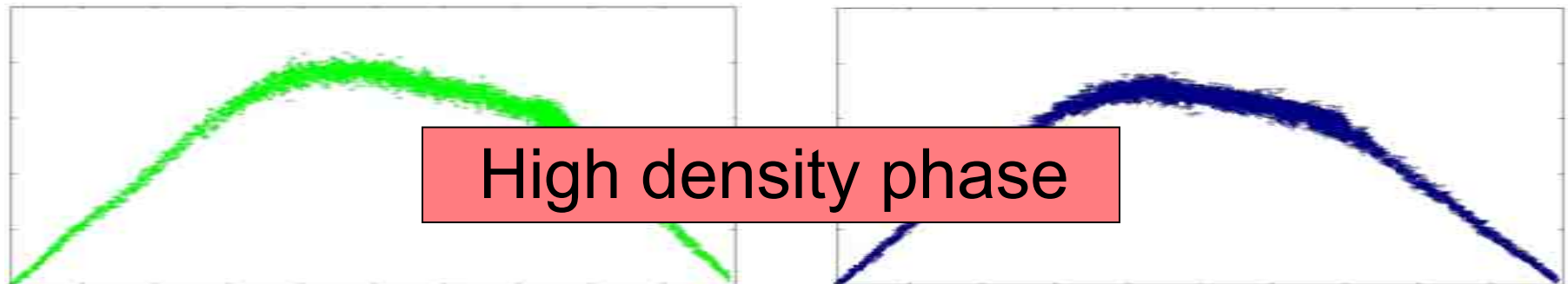
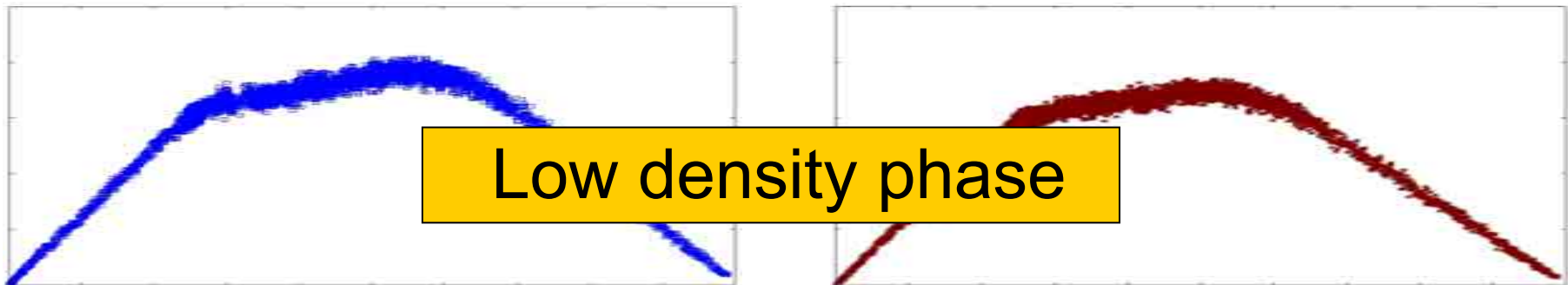
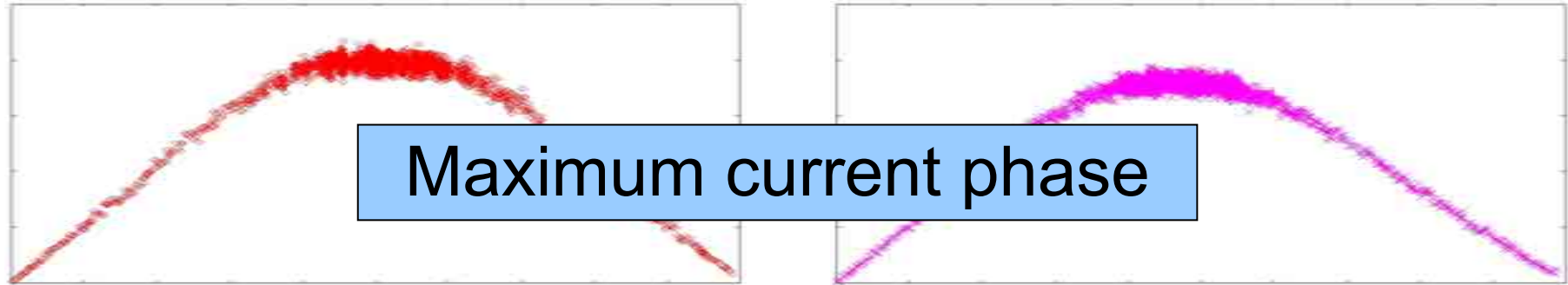
The value of a critical point is large in order of
Low density phase,
Maximum current phase,
High density phase.



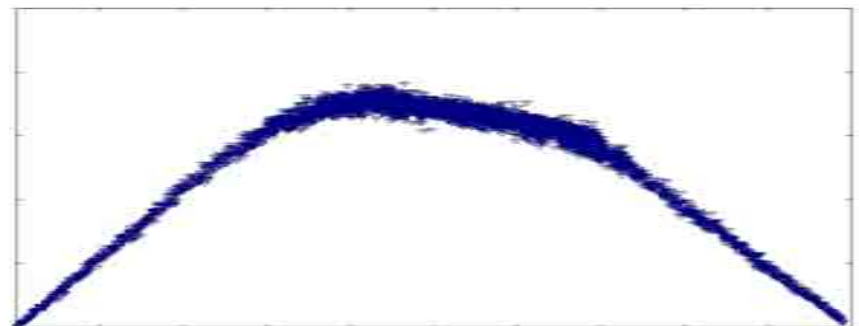
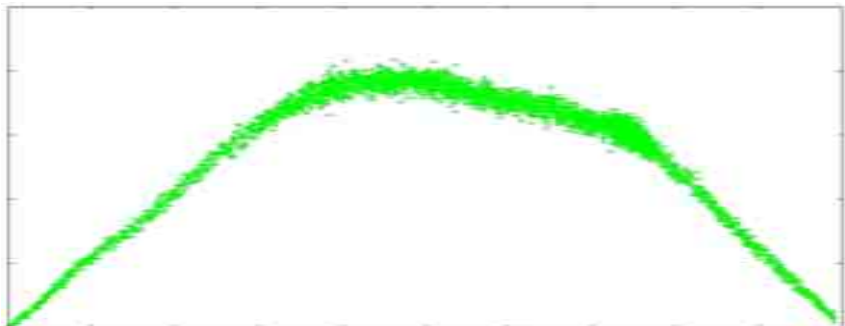
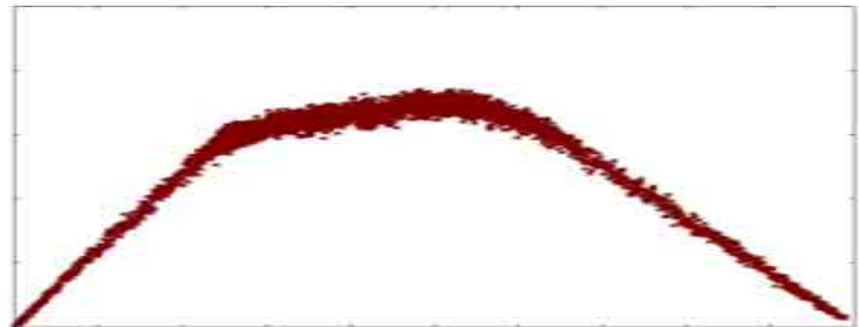
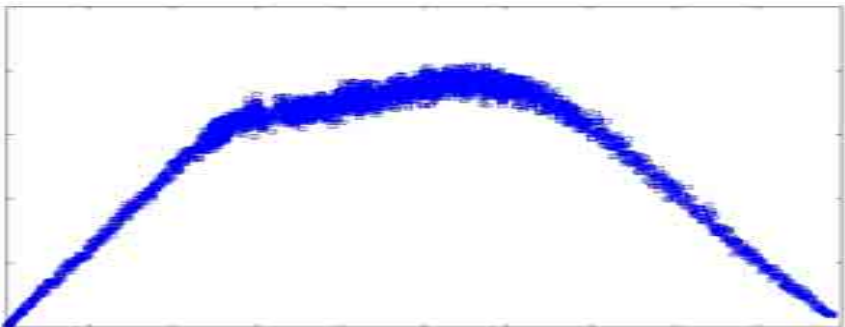
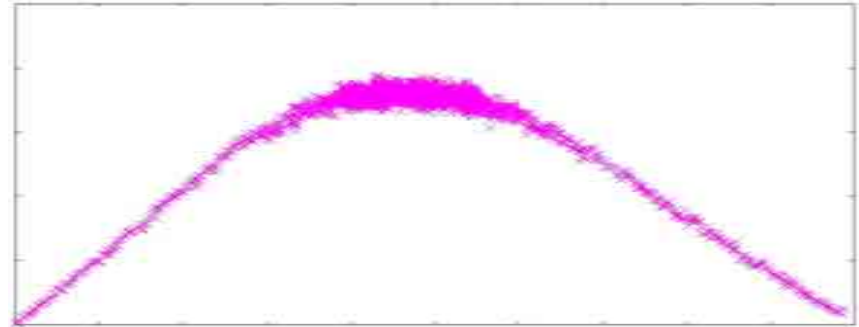
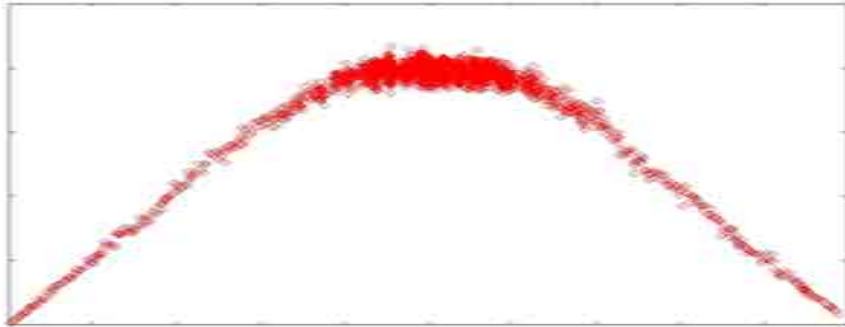
- Inertia breaking



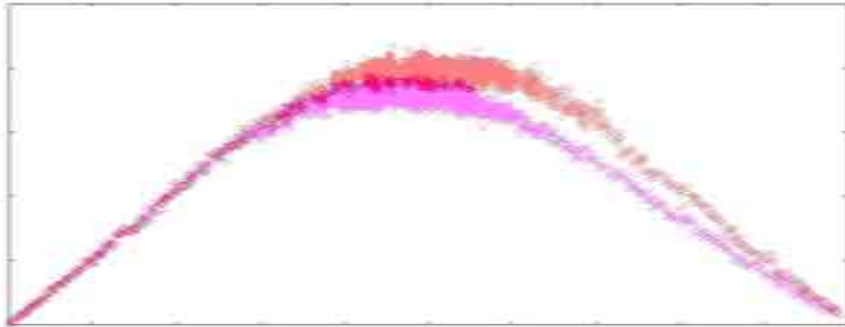
Comparison of two programming results



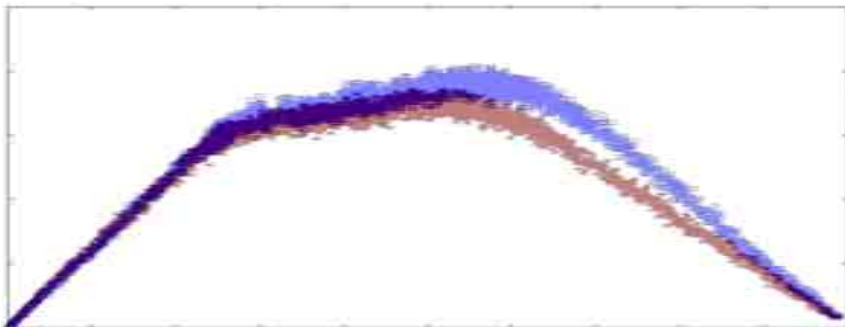
Comparison of two programming results



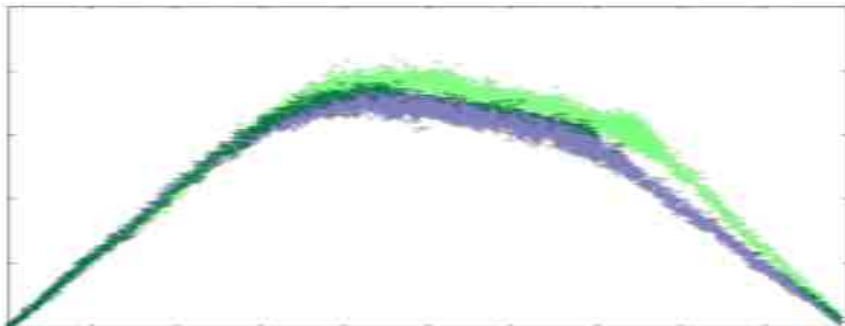
Comparison of two programming results



Maximum current phase

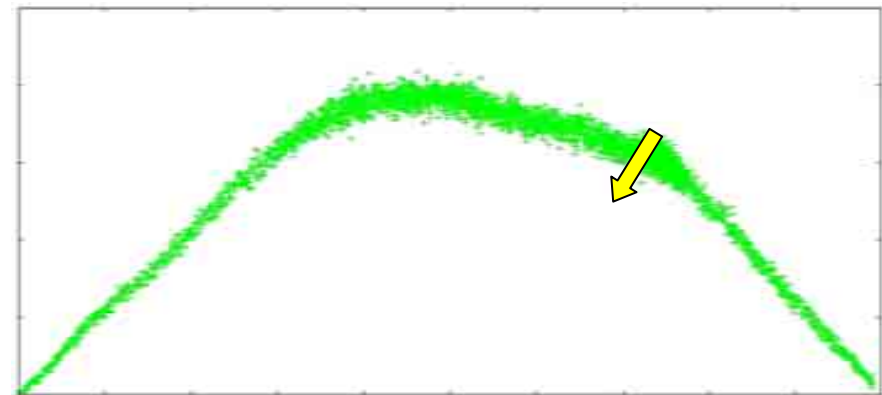
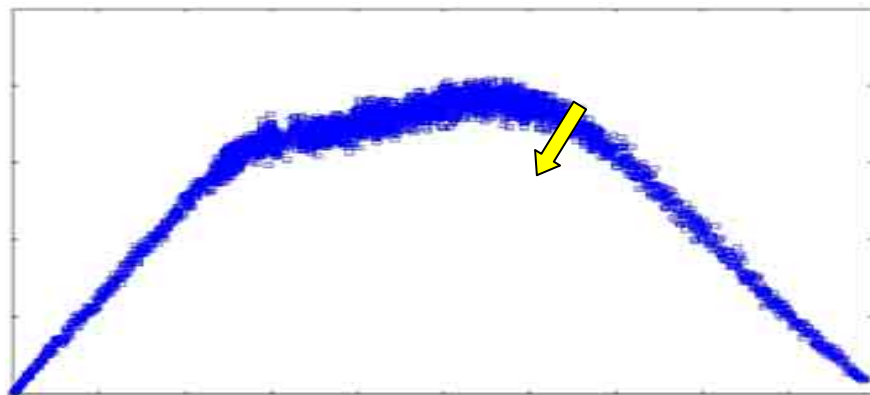
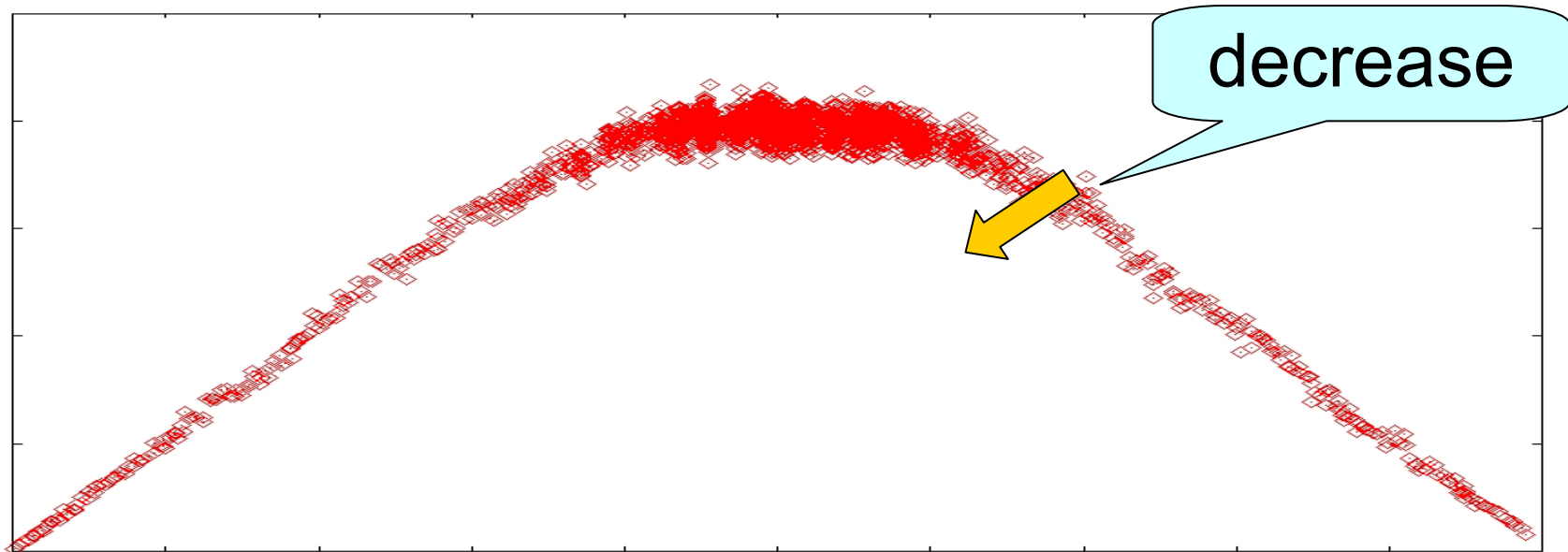


Low density phase

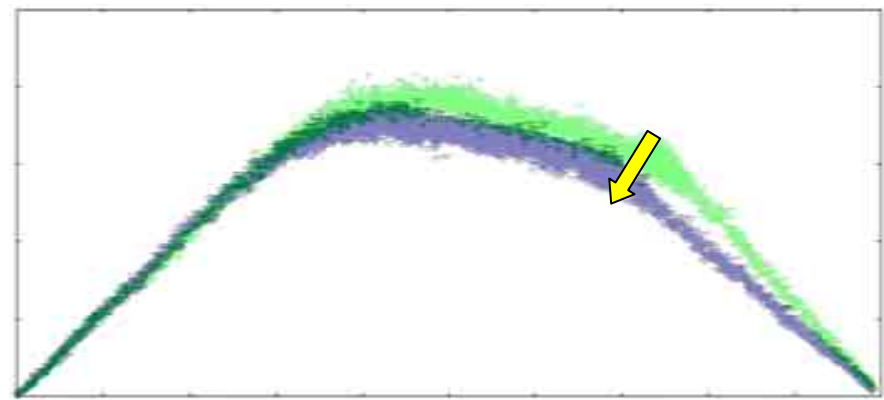
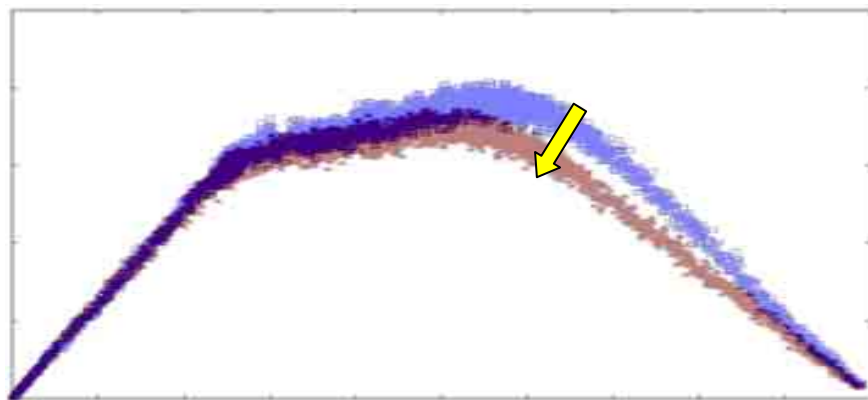
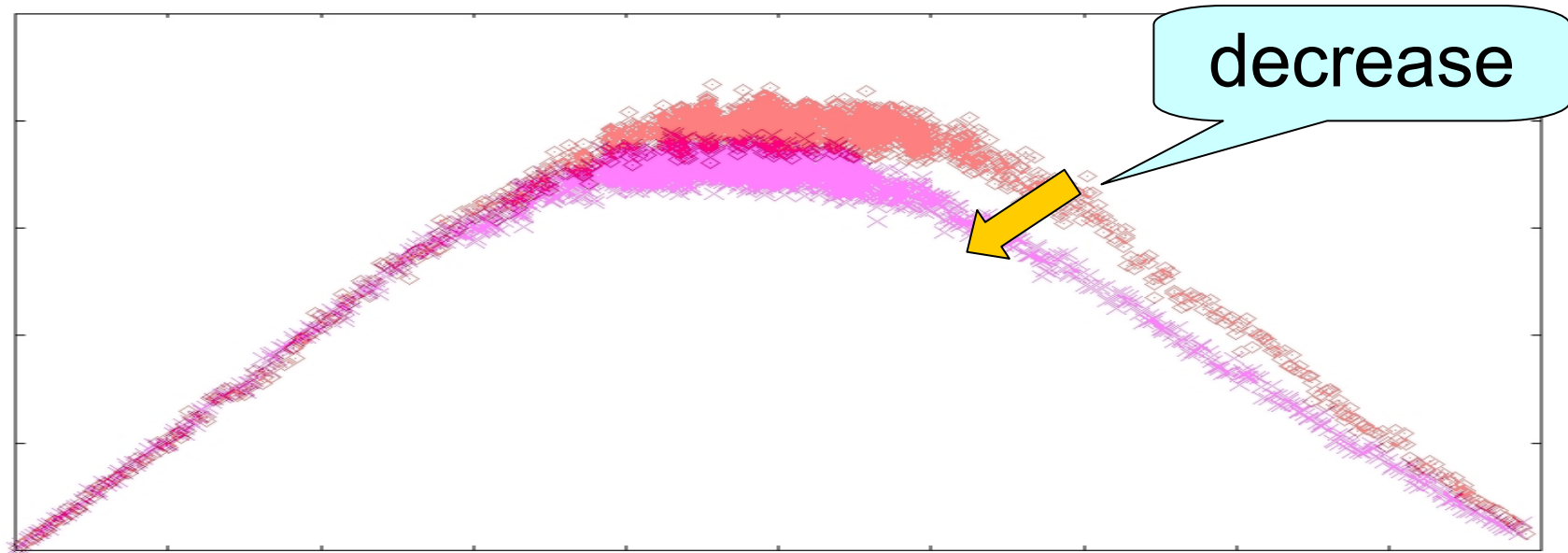


High density phase

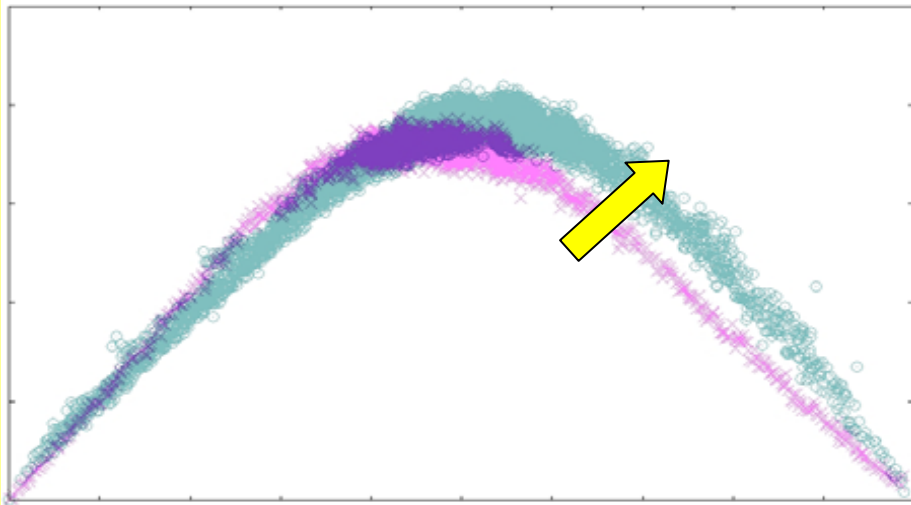
A critical density and flux decrease in three phase



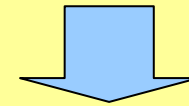
A critical density and flux decrease in three phase



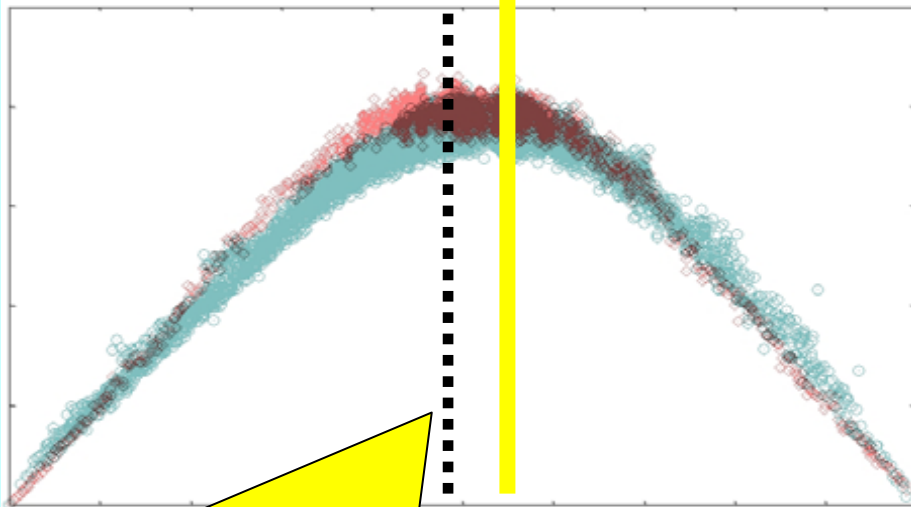
- Chasing



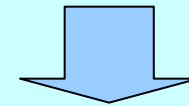
ASEP + Inertia breaking Model



ASEP + Inertia breaking
+ Chasing Model



ASEP



ASEP + Inertia breaking
+ Chasing Model

The critical density is higher than
the critical density of ASEP.



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- slow start

Metastable condition

Two states exist in same density.
Very unstable condition
, though it is not congestion.

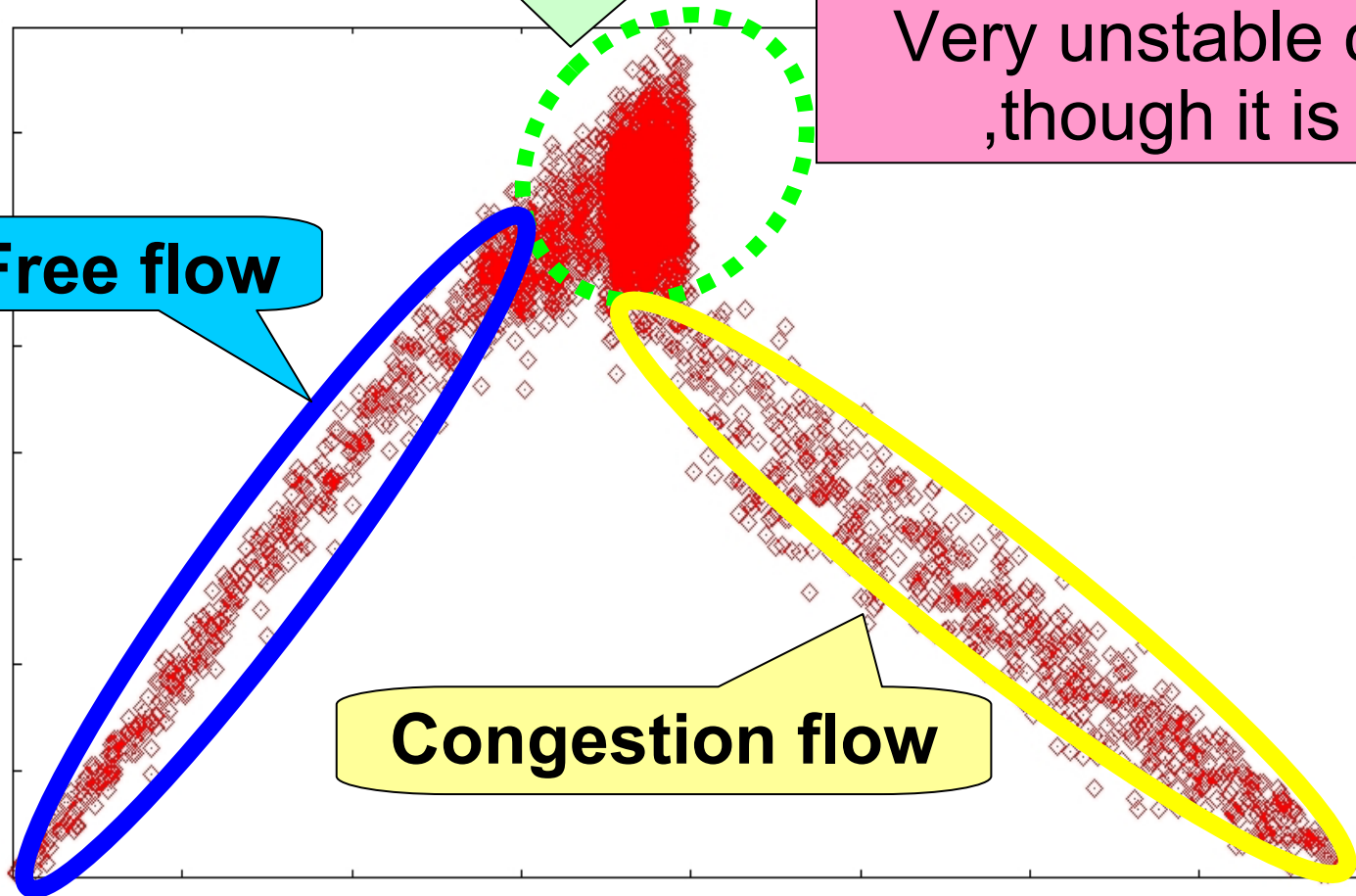
Free flow

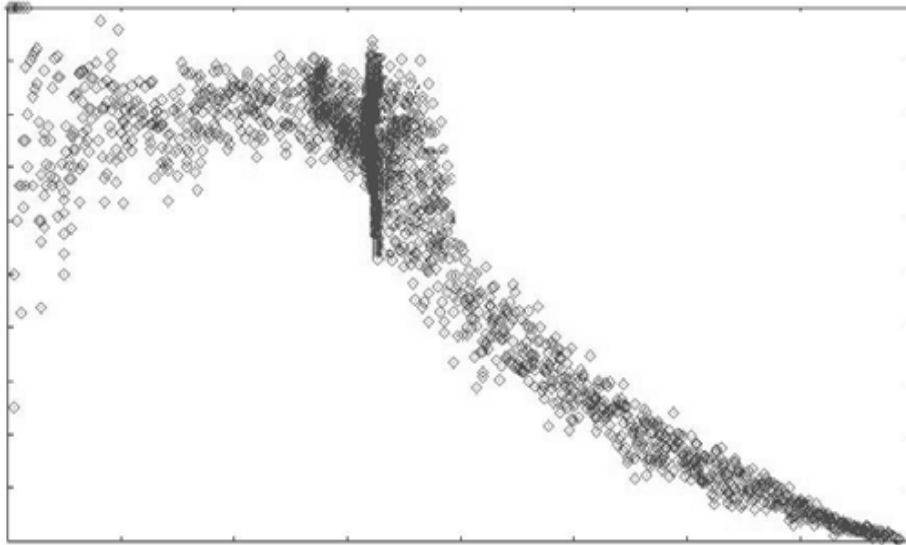
Congestion flow

ASEP + slow start Model

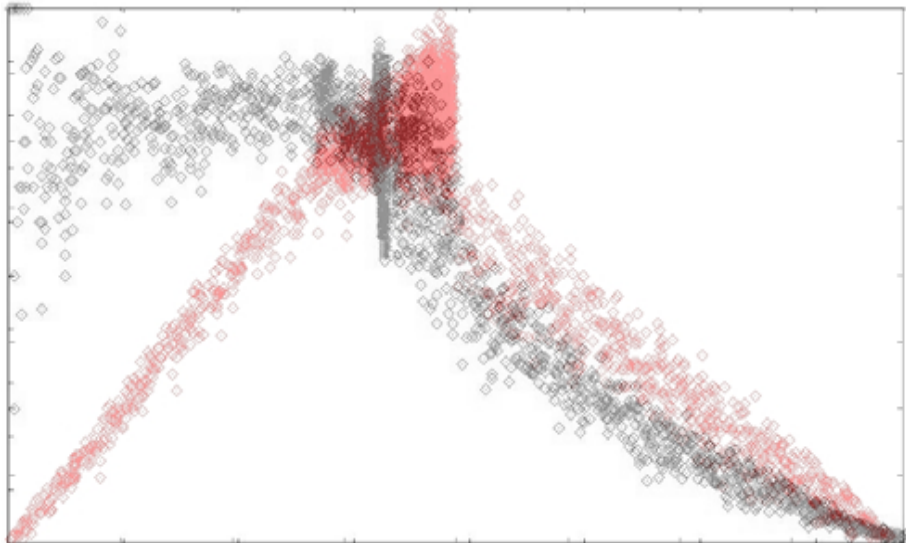


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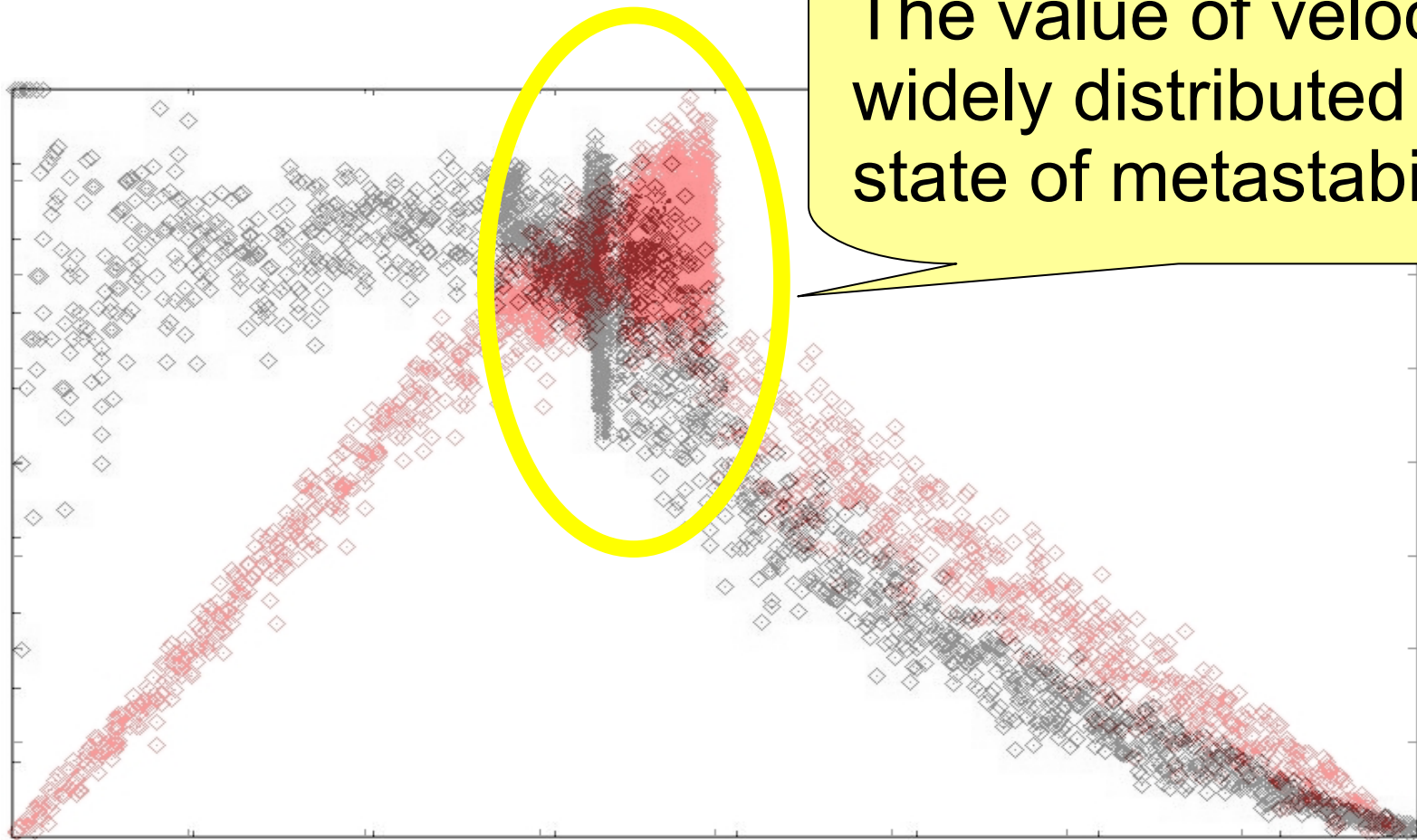




Graph of relation
between μ and $(\mu \times v)$

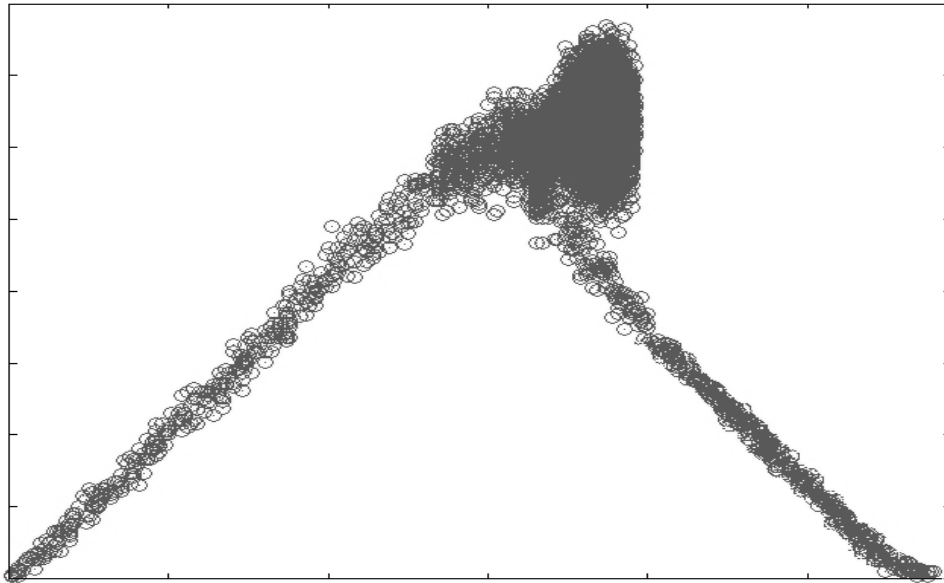


Graph of relation
between μ and v

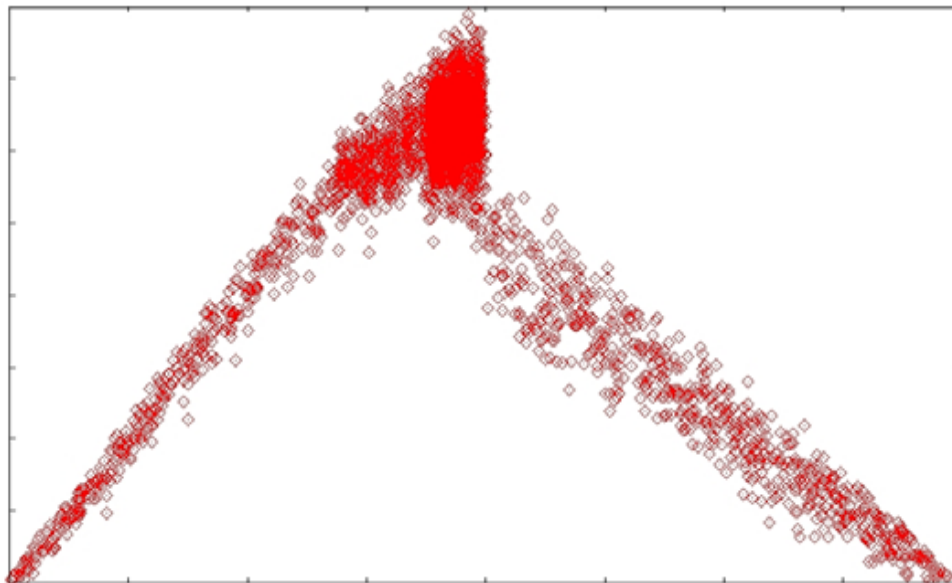


The value of velocity is widely distributed in the state of metastability.

- Program including all elements

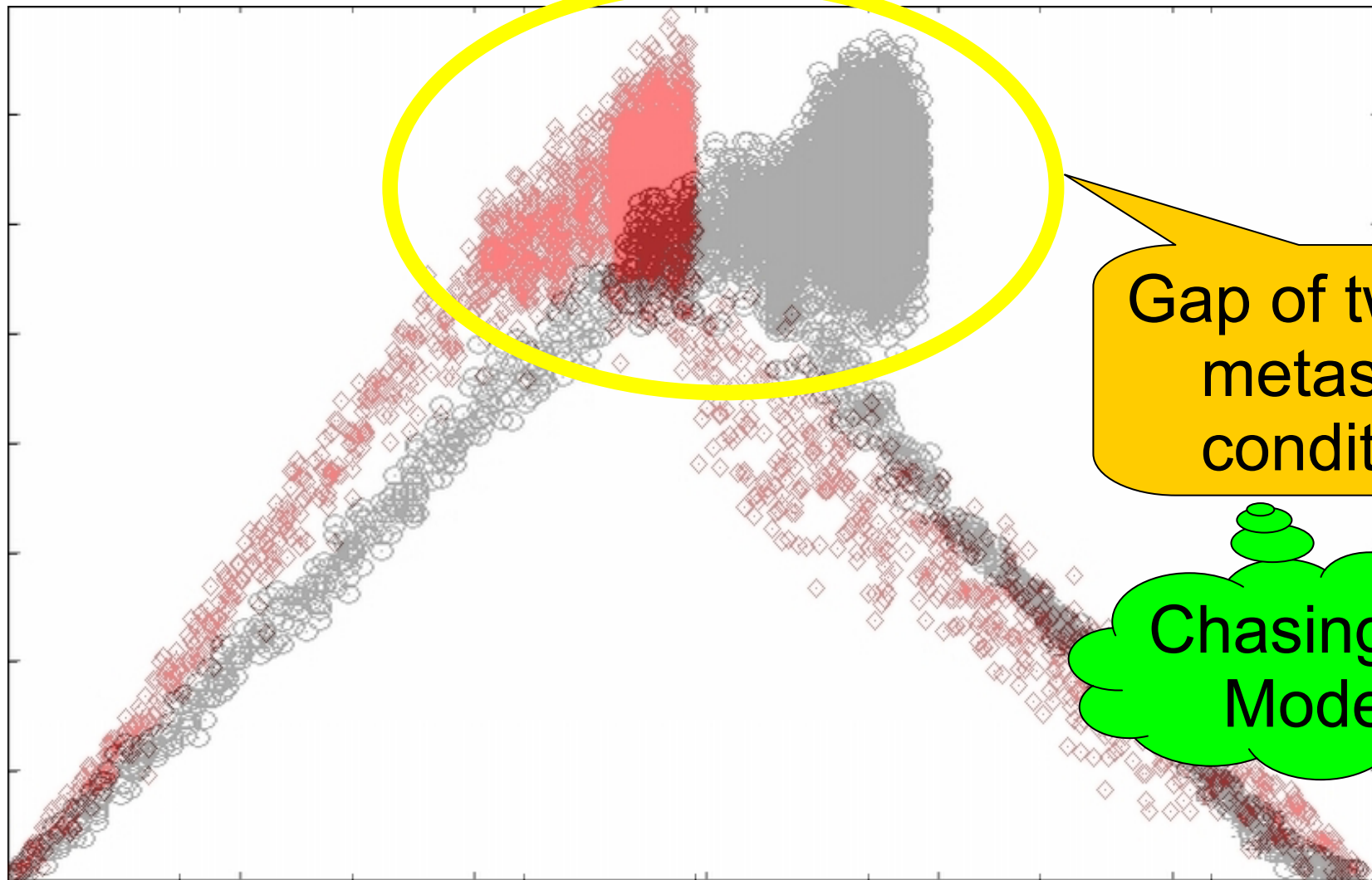


All including model



slow start Model

- Program including all elements

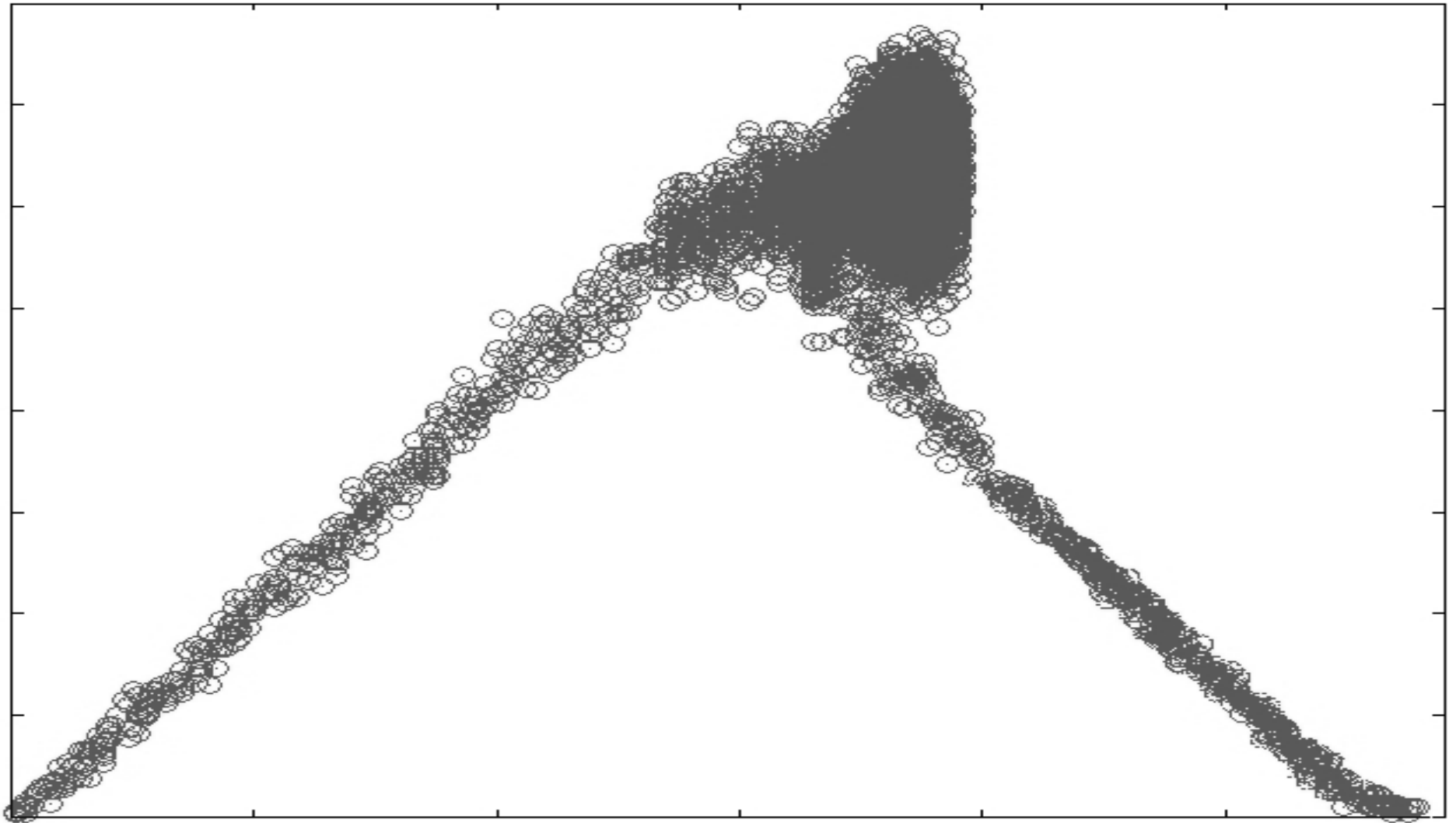


Gap of two
metastable
condition

Chasing
Model

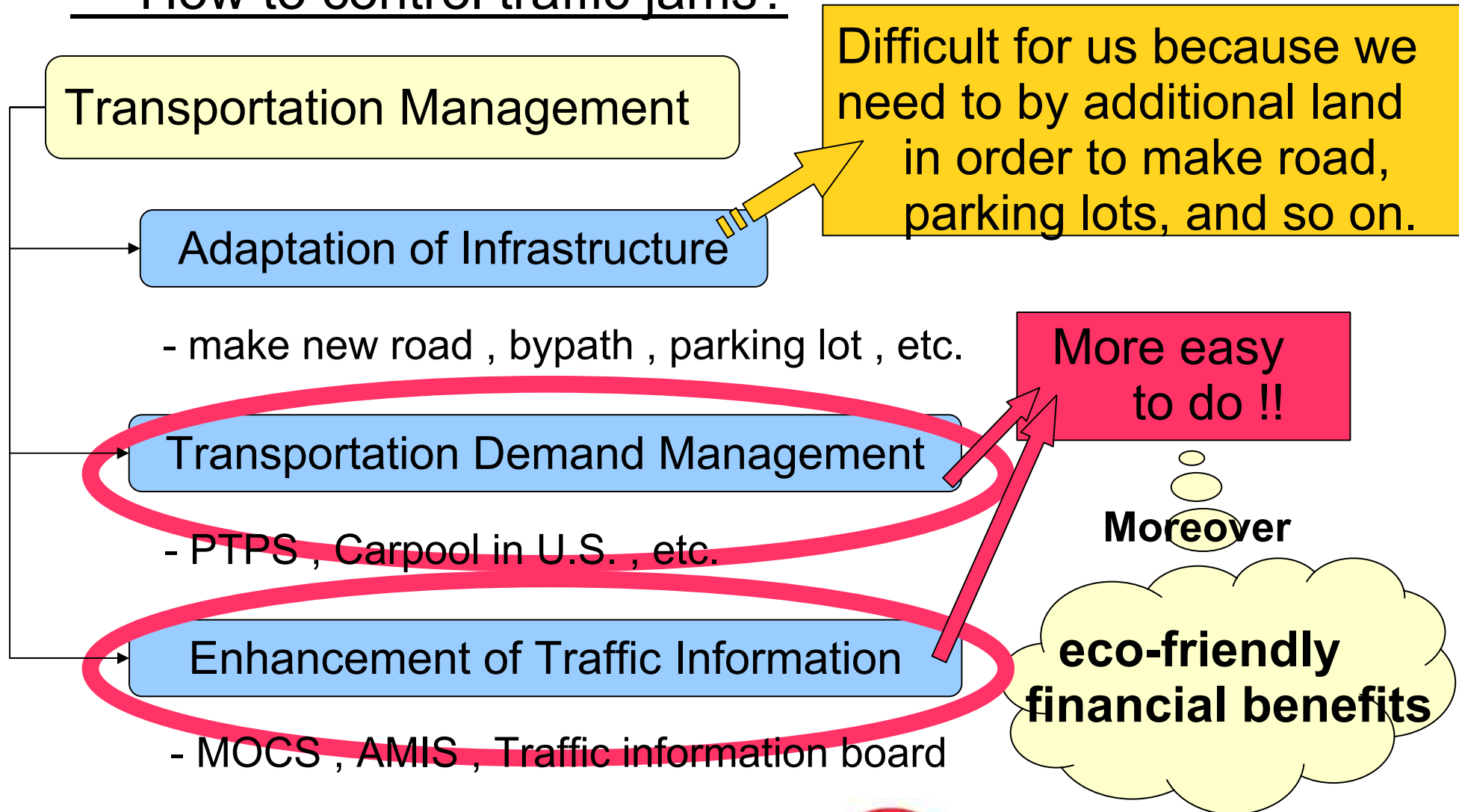


- Program including all elements



4 Actual traffic jam

How to control traffic jams?



• Transportation Demand Management

PTPS ; Public Transportation Priority Systems



System that attempts improvement of convenience of bus by signal control, lane only for bus, and so on to give priority to public transportations.

Car pool lane / HOV lane

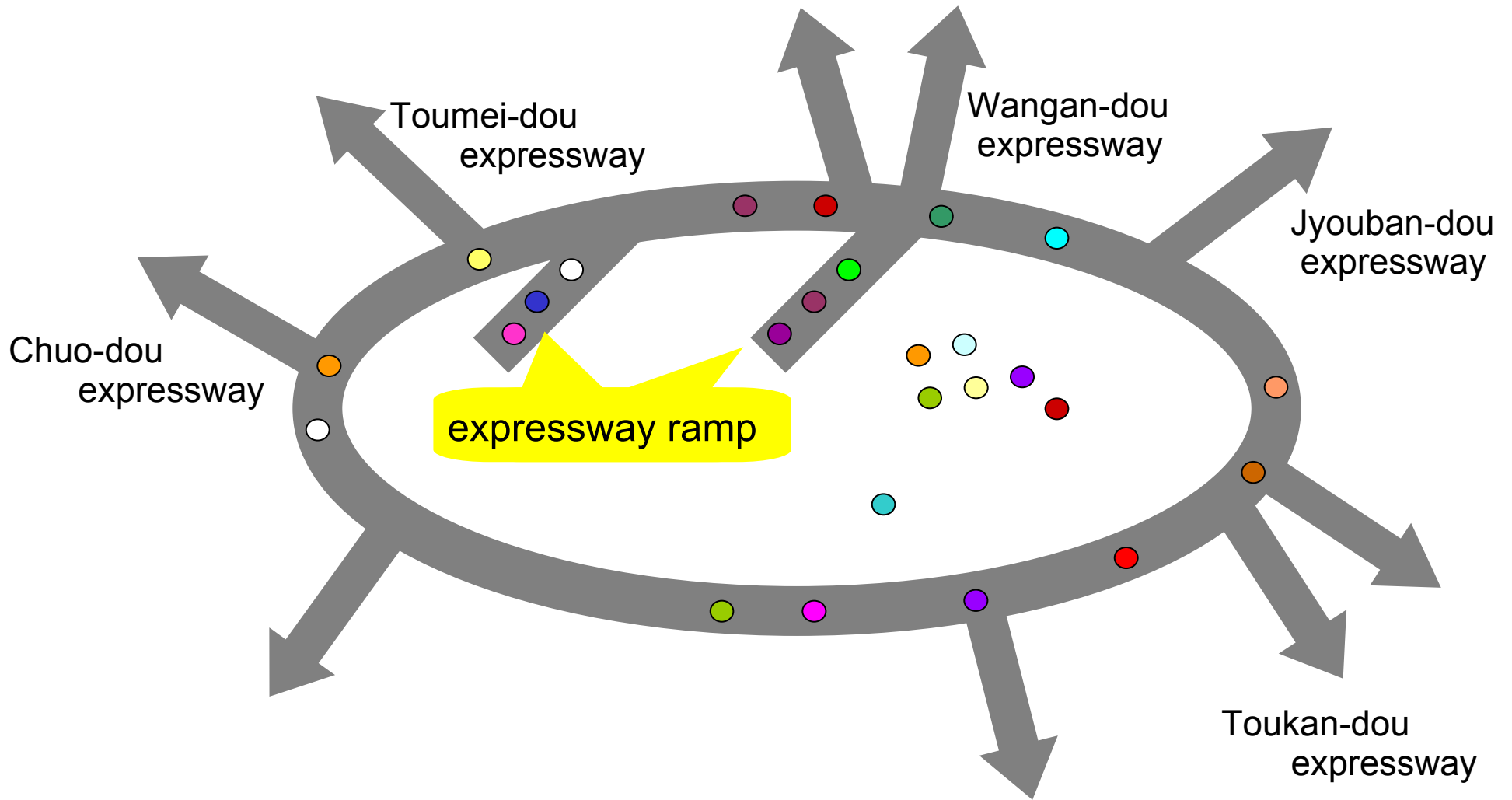
High-Occupancy Vehicles



Lane where only car that two people or more are boarding can run. The number of cars that run to promote riding together is decreased, and it is a congestion easing and a system that aims at the reduction of the vehicle exhaust emission.

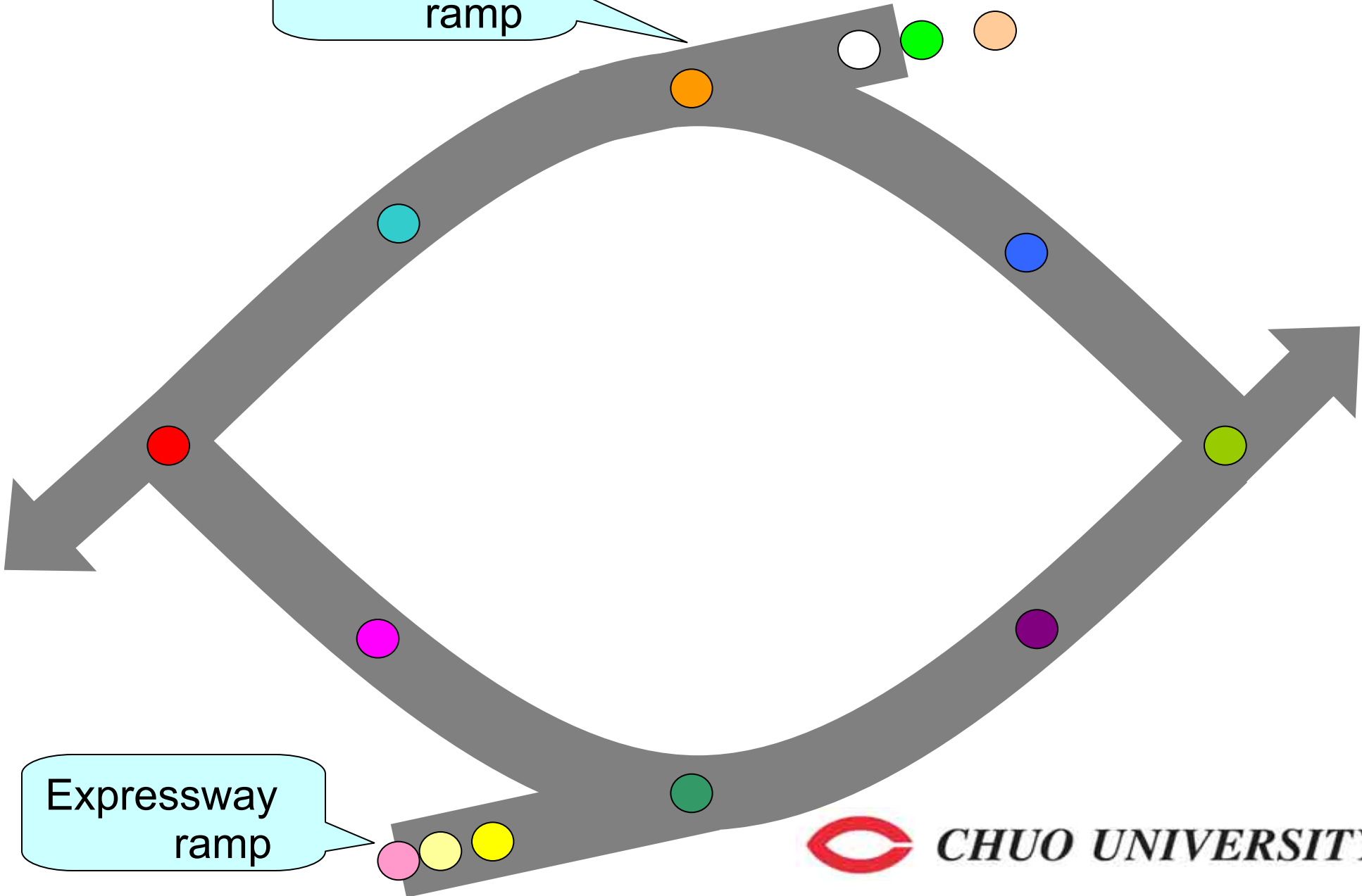


Adjustment of traffic...

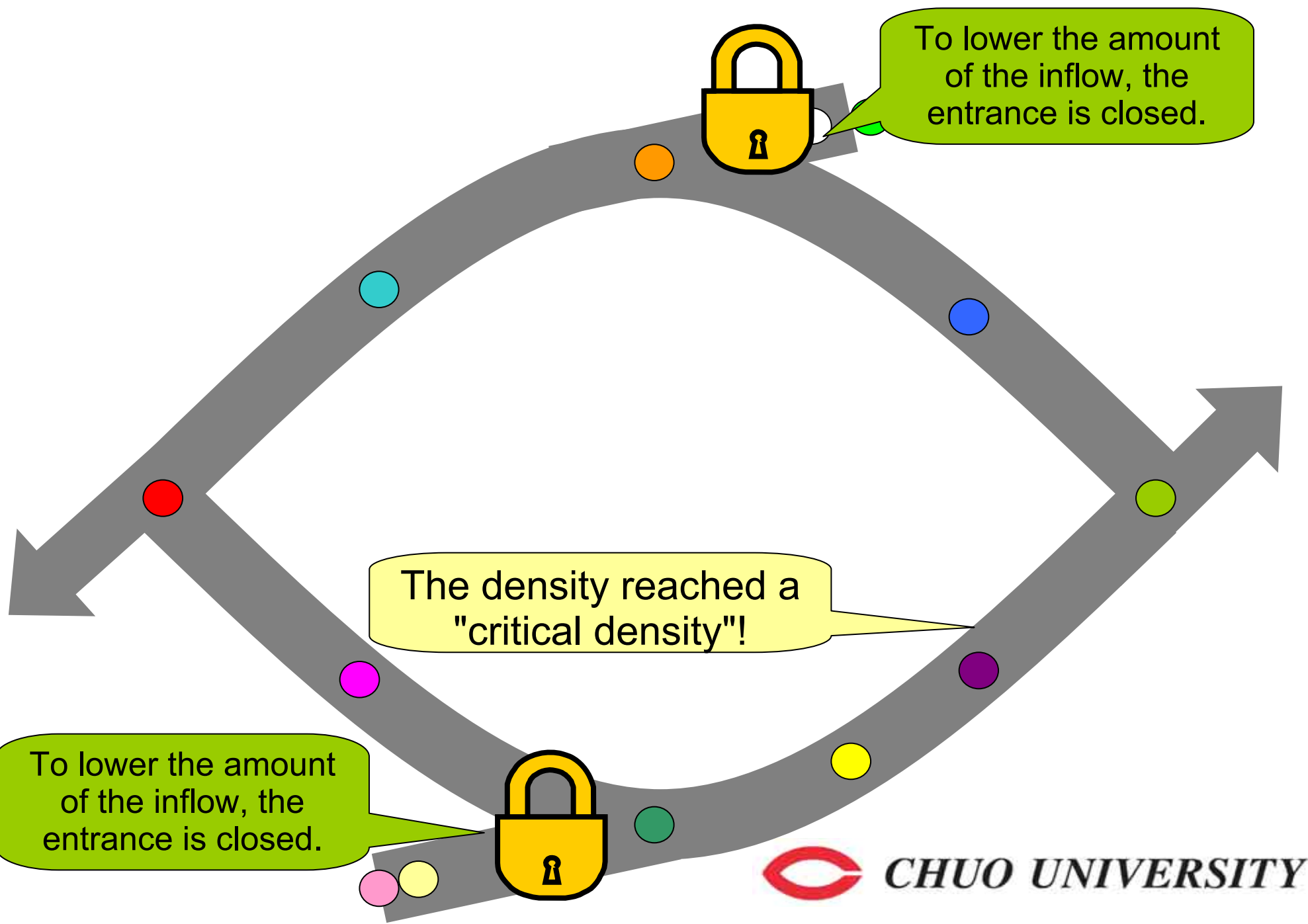


Tokyo Metropolitan Expressway

Expressway ramp



Expressway ramp



To lower the amount of the inflow, the entrance is closed.

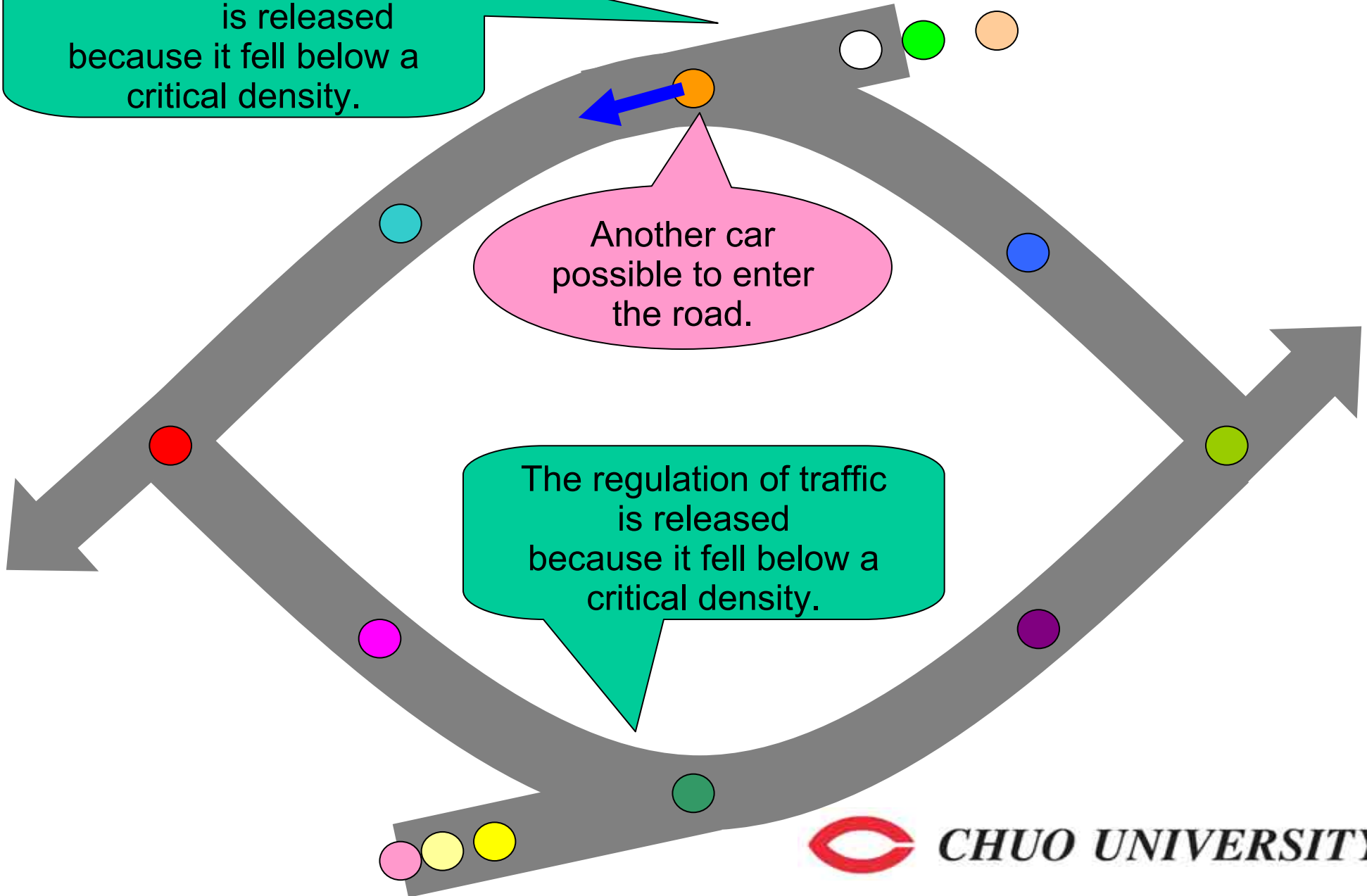
The density reached a "critical density"!

To lower the amount of the inflow, the entrance is closed.

The regulation of traffic is released because it fell below a critical density.

Another car possible to enter the road.

The regulation of traffic is released because it fell below a critical density.



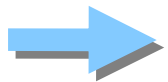
- Enhancement of Traffic Information

MOCS ; Mobile Operation Control System



The traffic data collected by the optical beacon and the vehicle detector is processed, analyzed, edited with the computer of a traffic Mission Control, and it inputs it.

AMIS ; Advanced Mobile Information Systems

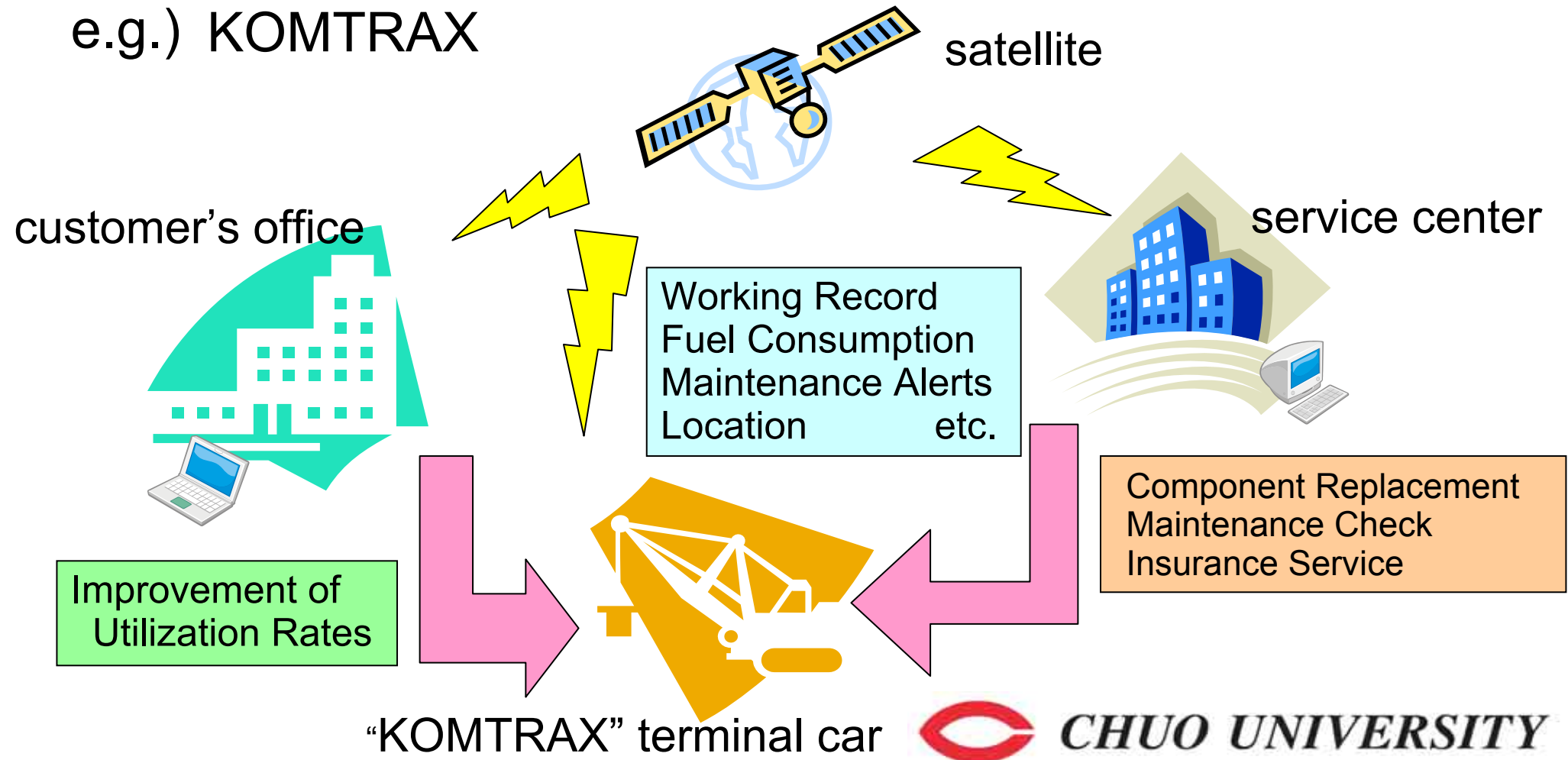


System that offers traffic information collected in traffic Mission Control through various media such as information board, car radios, and car navigations.

As an application...

MOCS and AMIS are applied also in the business field !

e.g.) KOMTRAX



Summary

- It has been understood that there are a lot of common parts with actual traffic management and ASEP.
- In addition, it was able to be confirmed that an actual road traffic policy by the experience rule was reasonable.
- I want to analyze the Model of two lanes in the future if there is an opportunity.



**Thank you for listening
my presentation !**

