Introduction to transportation planning

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Lecture 7
Traffic flow models

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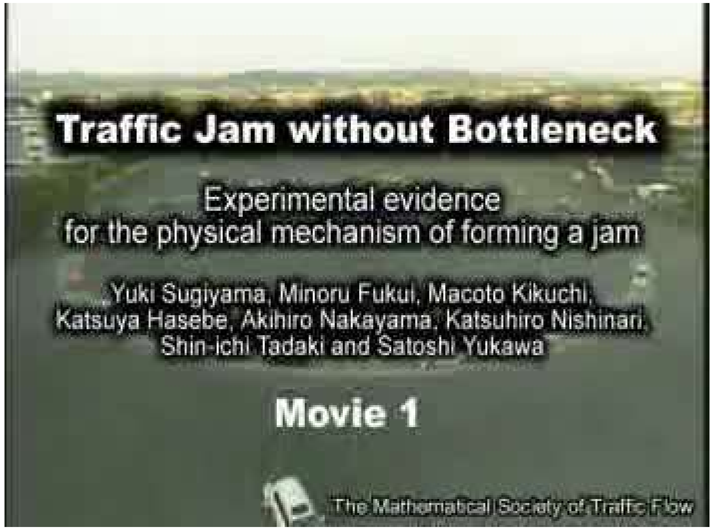
Traffic flow dynamics



Traffic flow dynamics

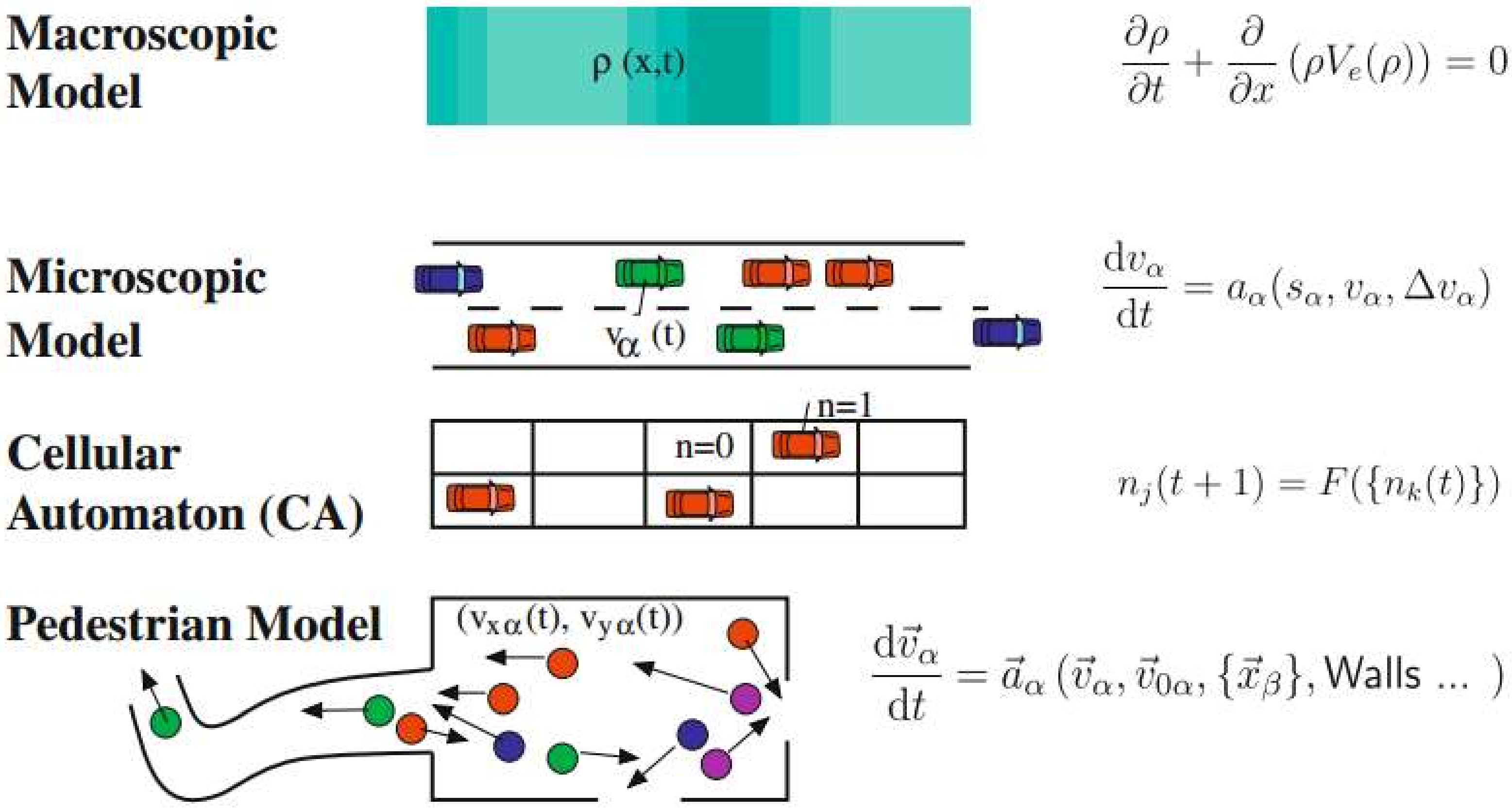
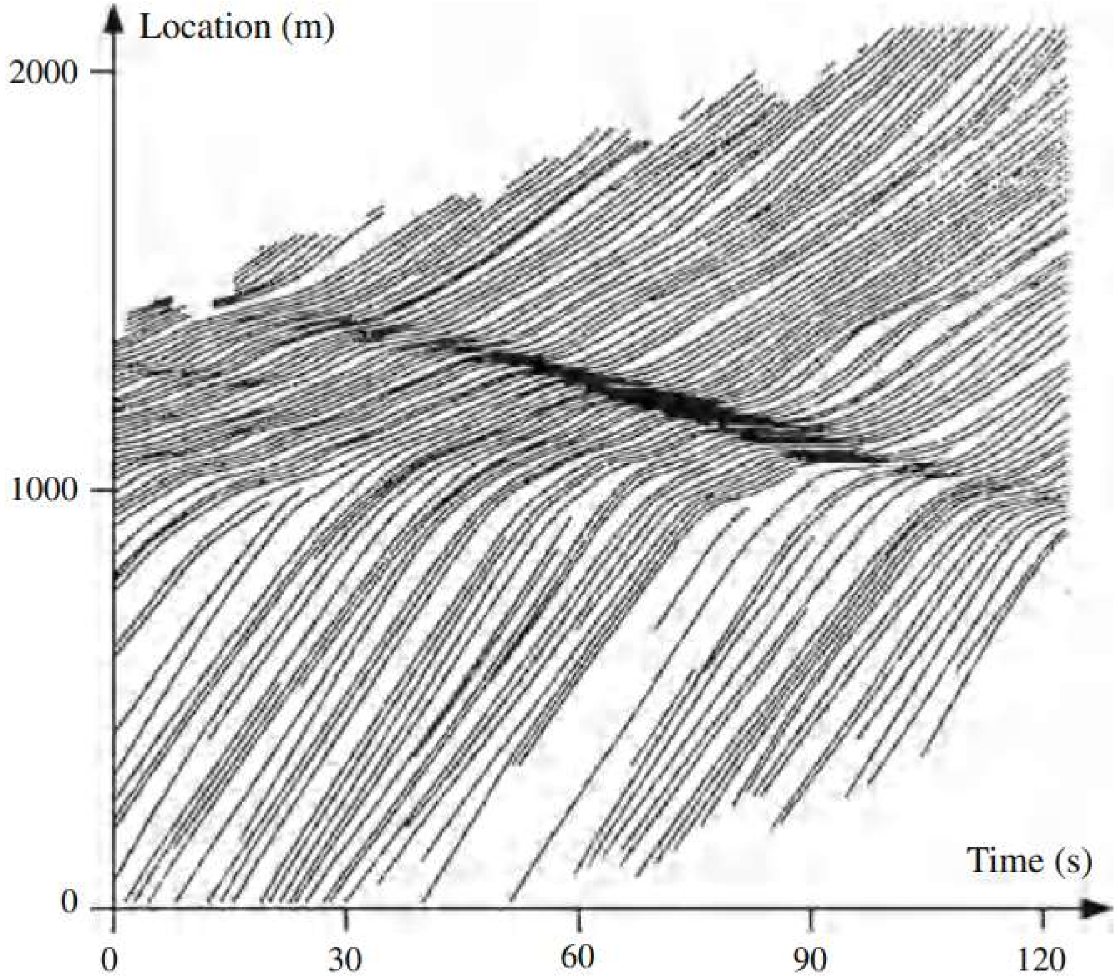
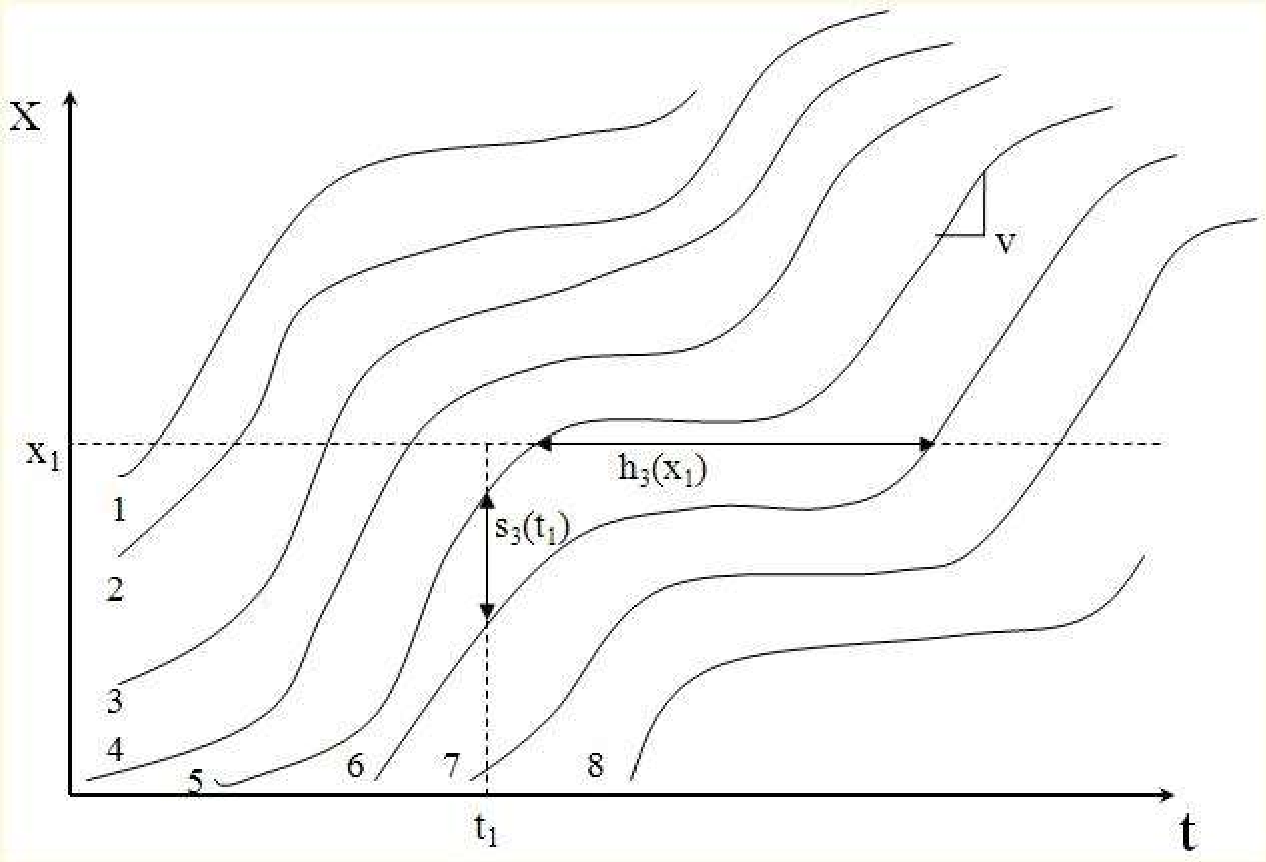


Fig. 6.2 Comparison of various model categories (with respect to the way they represent reality) including typical model equations

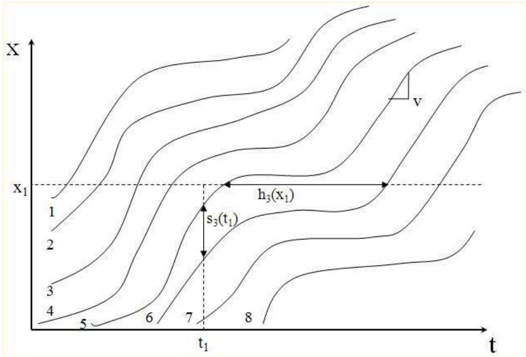
Trajectories (observed)



Space-time trajectory

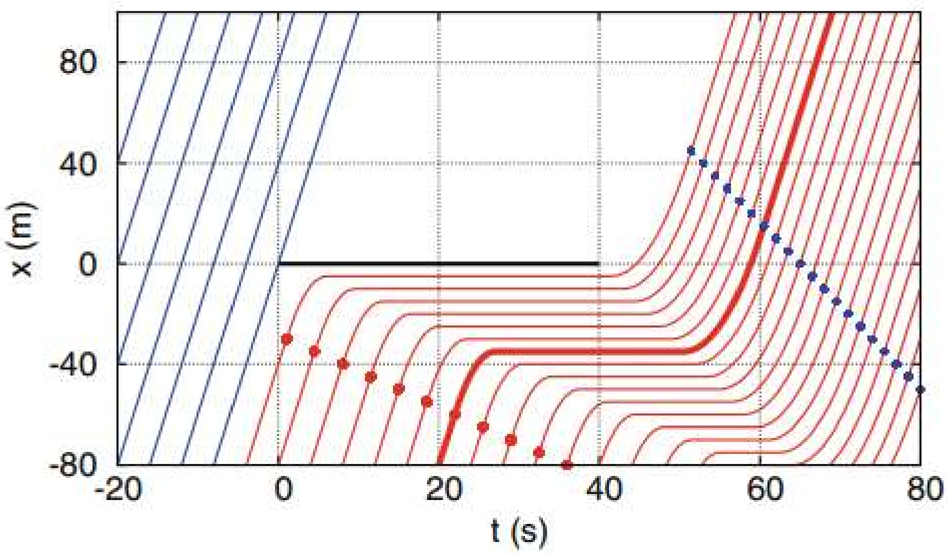


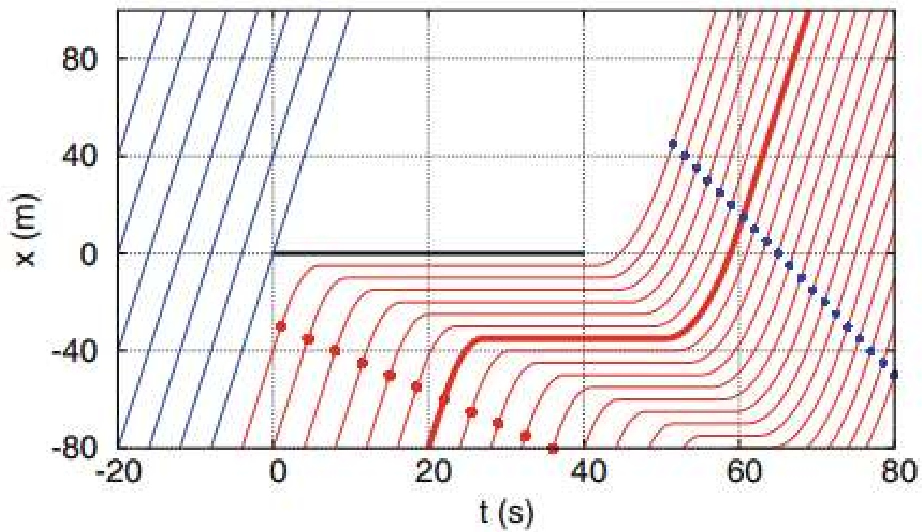
Traffic parameters



- speed
  - space-mean speed
  - time-mean speed
- number of vehicles at link at time τ
- flow (number of vehicles during time interval Δτ)
- density (number of vehicles per km Δx)

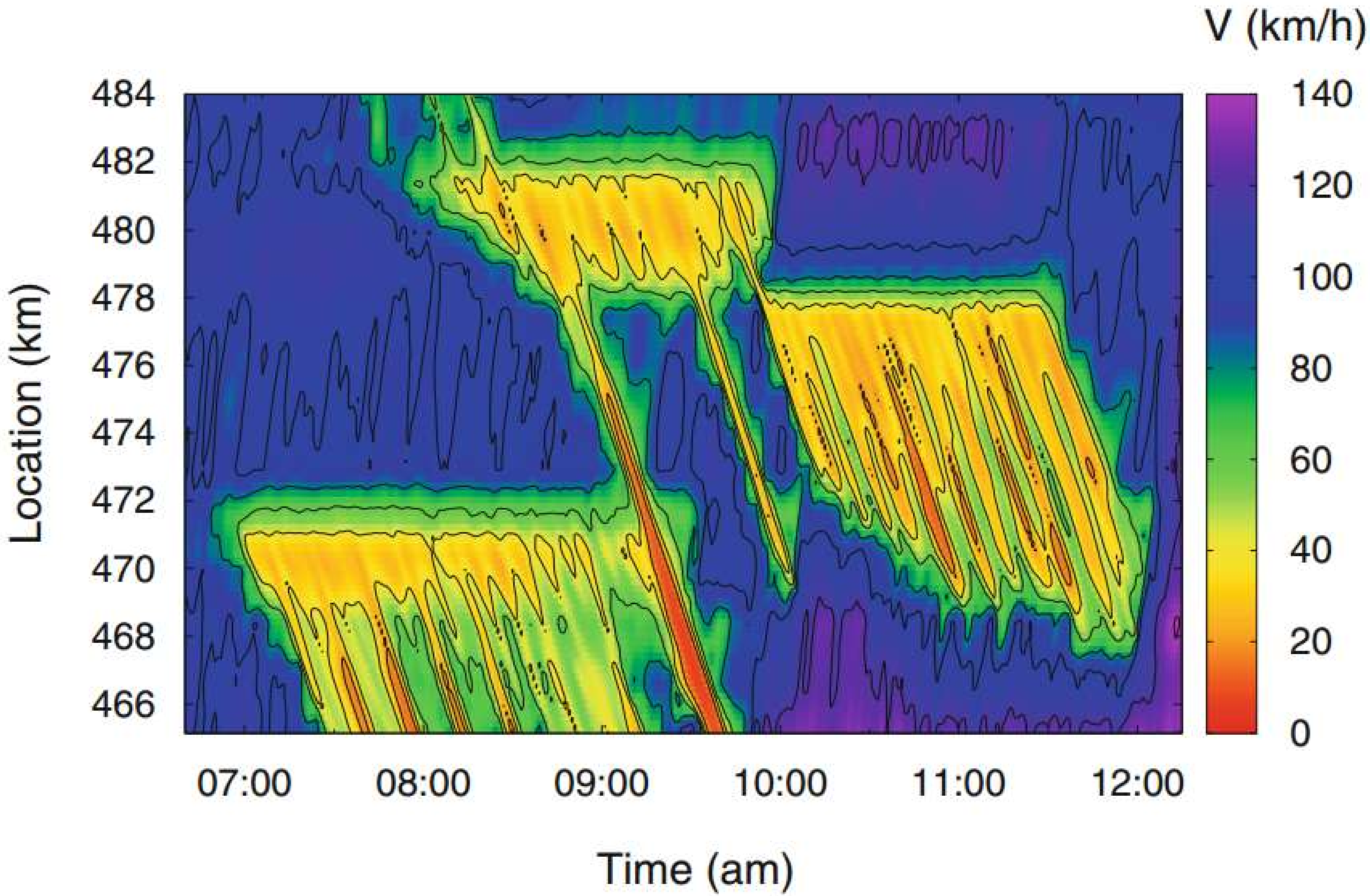
Red light





1. What situation is shown? What does the horizontal bar beginning at $x = t = 0$ mean?
2. Determine the traffic demand, i.e. the inflow for $t \leq 20$ s.
3. Determine the density and speed in the free traffic regime upstream of the "obstacle".
4. Determine the density within the traffic jam.
5. Determine the outflow after the "obstacle" disappears. Also find the density and speed in the outflow regime after the initial acceleration (the end of which is marked by smaller blue dots).
6. Determine the propagation speed of the transitions "free traffic → jam" and "jam → free traffic".
7. What travel time delay is imposed on a vehicle entering the scene at $t = 20$ s and $x = -80$ m?
8. Find the acceleration and deceleration values (assuming they are constant). The start of the deceleration phase and the end of the acceleration phase of each vehicle are marked by dots.

Space-time-speed diagram



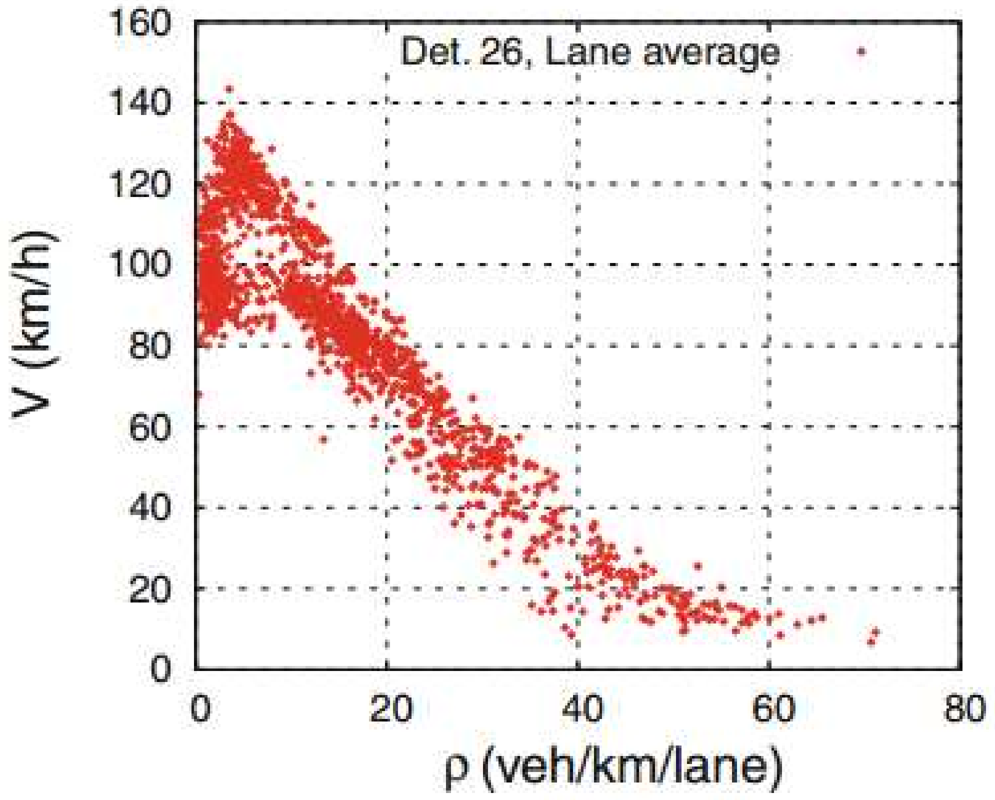
Macroscopic models

- q, k, v

flow, density, speed (average)

- vehicles → continuous flow

Flow – density relation



Fundamental diagram

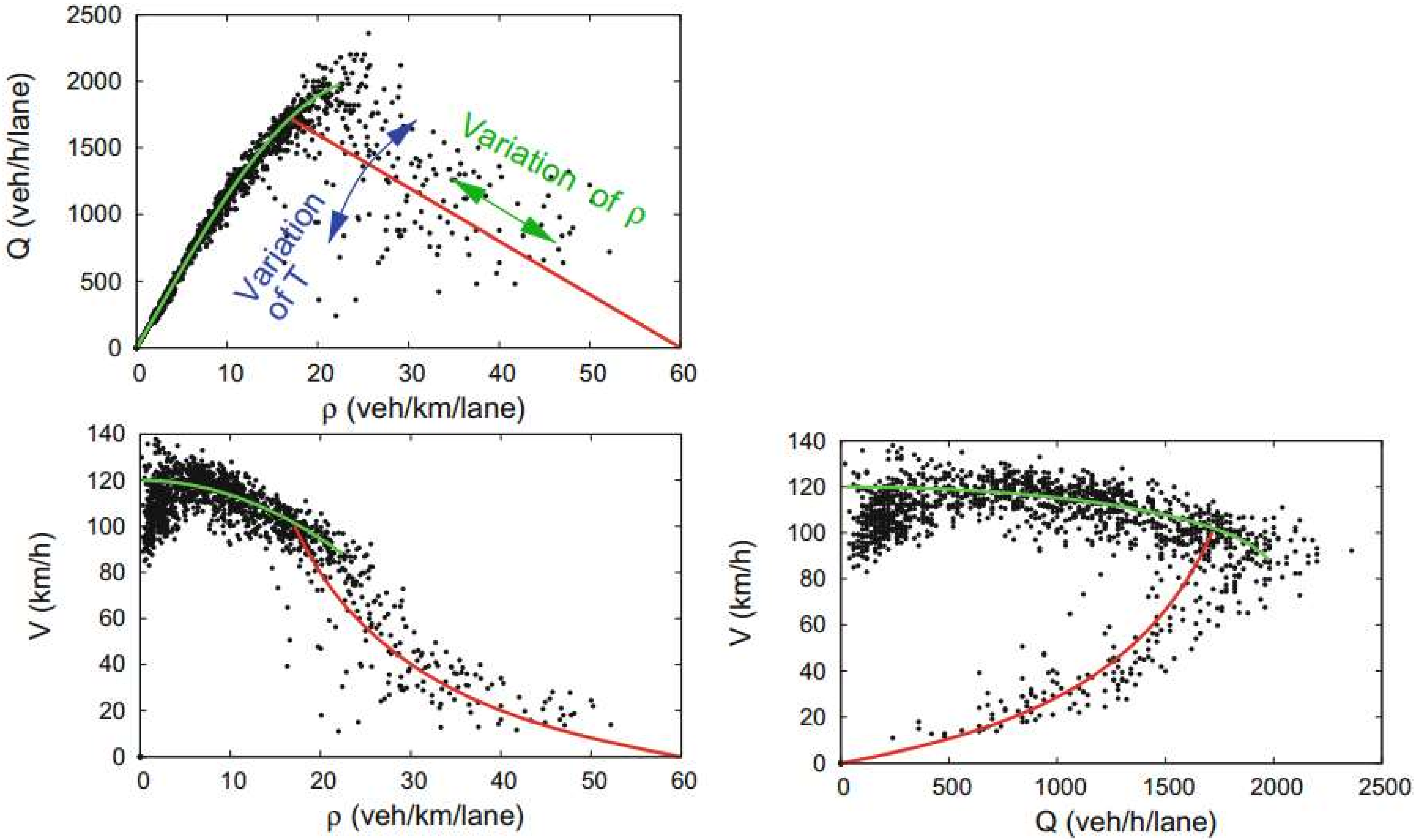
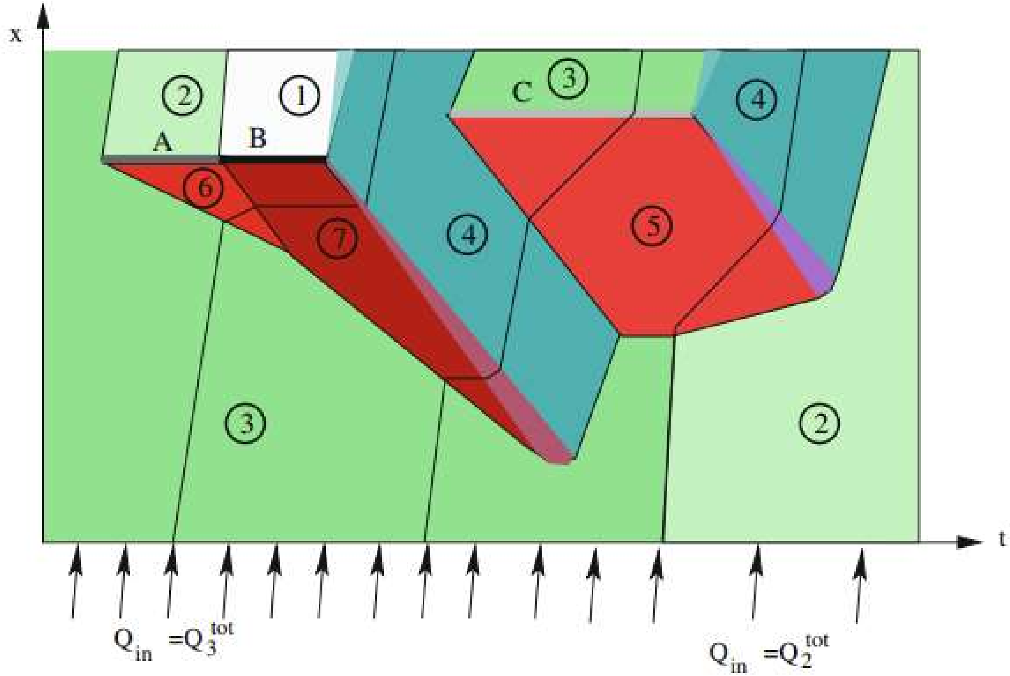


Fig. 4.12 Flow-density, speed-density, and speed-flow diagrams of the 1-minute data captured on the Autobahn A5 near Frankfurt, Germany using harmonic mean speed. The lines show the fit of a traffic-stream model (see Sect. 6.2.2)

Simplified theory of kinematic waves



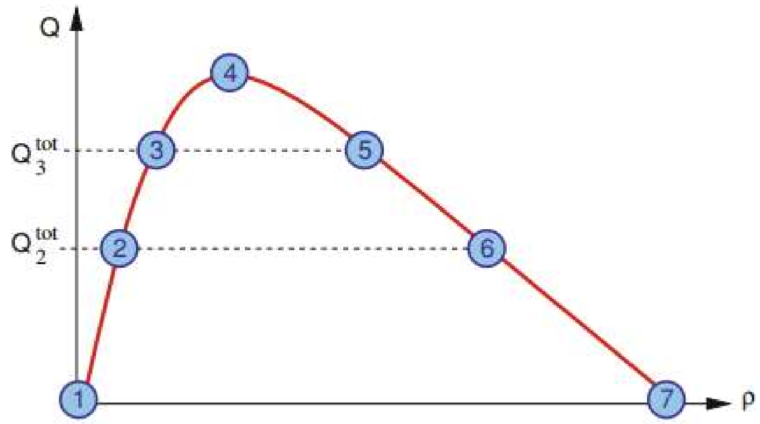


Fig. 8.7 Spatiotemporal traffic dynamics of an LWR model with fundamental diagram as shown in Fig. 8.8. The influx Q_{in} corresponds to state ③ in the fundamental diagram, but decreases after some time and then corresponds to state ②. Furthermore, there are three temporary bottlenecks: Bottleneck A (e.g., a traffic accident) has capacity $C_A = Q_2^{\text{tot}}$, bottleneck B corresponds to a temporary full road closure (e.g., to tow away vehicles involved in the accident), and bottleneck C is a less severe obstruction with capacity $C_C = Q_3^{\text{tot}}$. The slopes of the three trajectories (*black*) indicate the local vehicle speed. The transitions from high to low density "soften" over time while the others remain discontinuous, i.e., shocks

Microscopic models

- vehicle (agent)
- making decisions in each time-step
- decision:

  accelerate, decelerate, change lane, start/stop.

Microscopic vehicles

a_n	Acceleration, vehicle *n*, [m/s^2]
x_n	Position, vehicle *n*, [m]
v_n	Speed, vehicle *n*, [m/s]
Δx	$x_{n-1} - x_n$, space headway, [m]
Δv	$v_n - v_{n-1}$, difference in speed, [m/s]
$v_n^{desired}$	Desired speed, vehicle *n*, [m/s]
L_{n-1}	Length, vehicle *n-1*, [m]
s_{n-1}	Effective length (L_{n-1} + min gap between stationary vehicles), vehicle *n-1*, [m]
T	Reaction time, [s]

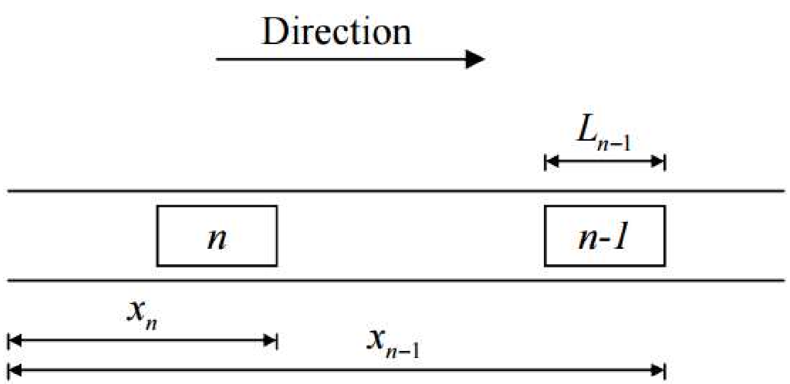


Figure 1 *Car- following notation.*

Car-following model

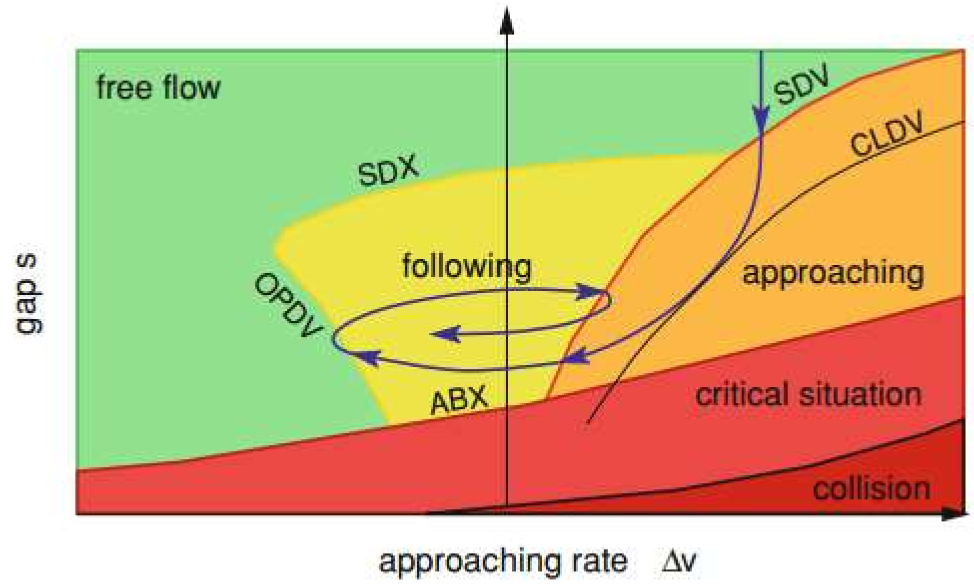


Fig. 12.5 Schematic and simplified representation of the regimes of the Wiedemann model in the three-dimensional state space spanned by s, v, and Δv. Shown are the intersections of the regimes and their boundaries with the plane $v_l = v - \Delta v =$ constant (the leader drives at constant speed v_l). The *blue line* shows the trajectory of a vehicle approaching a slower vehicle in the projected state space. The speed-difference thresholds CLDV ("closing in"), OPDV ("opening"), SDV ("sensitivity threshold"), and the gap-related thresholds ABX and SDX (minimum and maximum gap in car-following regime) are denoted as in the literature

Microscopic model

Macroscopic model

Static, macroscopic

$t_a(\tau)$ travel time of arc a at time τ