Transportation on the rotary

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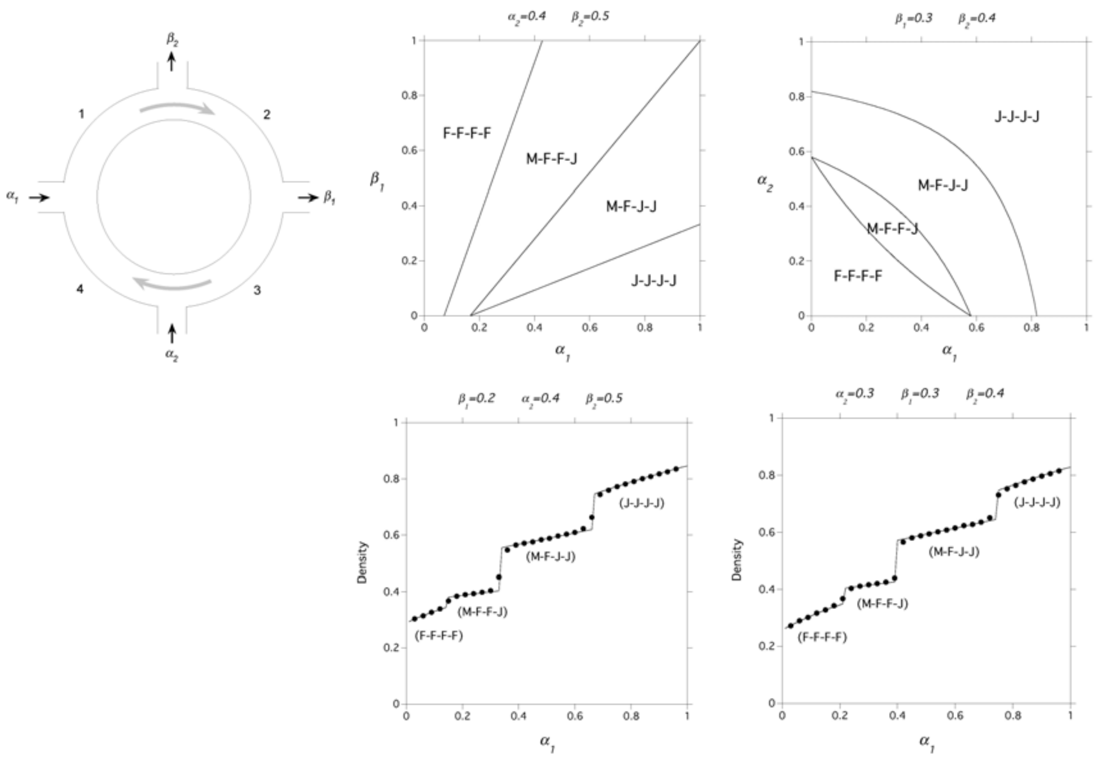
We model the mass transportation on the rotary by cellular automata. Both space and time are discretized. The dynamics is prescribed by the Asymmetric Simple Exclusion Processes (ASEP). Various on- and off-ramps are introduced to allow particles moving in and out of the rotary. The ramps divide the rotary into consecutive sections, which are effectively homogeneous and can be characterized by free flow, jam, and maximum flow. Distinct phases of the traffic flow are classified completely. Exact phase diagrams are obtained. The bulk properties and the phase transitions are controlled by the operation of ramps. The ramps provide a mean to stabilize the density difference. Along the traffic direction, the jam will not follow free flow directly. When the jam does follow the free flow, there must involve a middle section of maximum flow. And the on-ramp must come before the off-ramp. With the analytical results, the bottleneck on the rotary can be easily identified.

In a special rotary with four ramps arranged as the following, there are four different phases. The bottleneck can only emerge in section 1. The typical phase diagrams and the analytical results are listed in the following. The numerical simulations can be correctly reproduced. We shall also present the results for some other interesting cases.



(Free – Free – Free – Free) $\alpha_1+\alpha_2+\alpha_1\cdot\alpha_2<\beta_1+\beta_2-\beta_1\cdot\beta_2$

(Jam – Jam – Jam – Jam) $\alpha_1+\alpha_2-\alpha_1\cdot\alpha_2>\beta_1+\beta_2+\beta_1\cdot\beta_2$

(Max – Free – Free – Jam) $\alpha_1+\alpha_2-\alpha_1\cdot\alpha_2<\beta_1+\beta_2-\beta_1\cdot\beta_2<\alpha_1+\alpha_2+\alpha_1\cdot\alpha_2$

(Max – Free – Jam – Jam) $\beta_1+\beta_2-\beta_1\cdot\beta_2<\alpha_1+\alpha_2-\alpha_1\cdot\alpha_2<\beta_1+\beta_2+\beta_1\cdot\beta_2$