Application of a steady states transport model to condensation of water droplets on a substrate

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Condensation of water droplets on a substrate proves as a good test ground for condensation phenomena in basic stochastic transport processes. The modeled physical situation consists of a substrate at constant temperature exposed to a constant influx of microscopic water droplets from surrounding vapor.

We consider a simple one-dimensional stochastic transport process with constant particle influx. This process can be parameterized so that particles condense to droplets.

The employed transport model consists of a periodic lattice and a gas of indistinguishable particles, so that each site i is occupied by zero or m_i particles. At every time step a random site i is chosen and a particle may leave to an adjacent site with probability proportional to a hopping rate $u(m_i|m_{i-1}, m_{i+1})$. The hopping rate is chosen so that particles tend to condensate by incorporating a zero-range repulsive interaction and surface tension like short-range interaction [1]. The envelope shape of condensates can be tuned to have the same scaling of volume to droplet width as real droplets [2]. Particle influx from environmental vapor is mimicked by adding at random sites randomly with a constant influx rate.

We compare our observations with a recent study of water droplet size distributions obtained in experiment and simulation by Blaschke et al. [3]. In the experiment water vapor condenses on a glass substrate. The simulation mimics experiment by adding a new constant initial volume droplet at some point to the substrate and subsequently merging any overlapping droplets at every time step.

In contrast to the previous simulations [3] our model intrinsically includes diffusion of particles and droplet merging occurs due to movement as well as particle placement in the influx step.
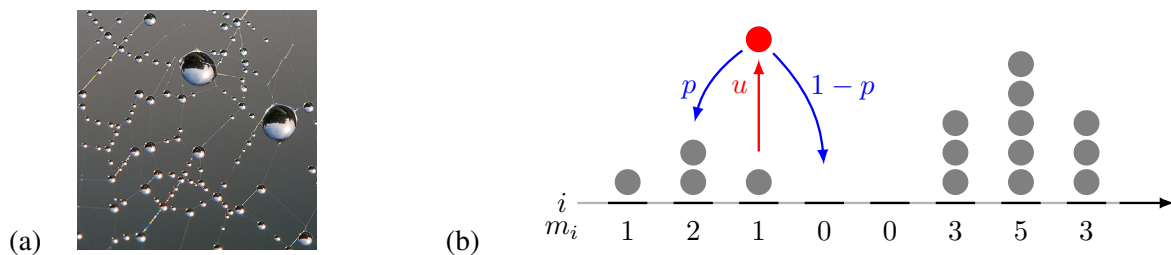

Figure 1: (a) Droplets of various sizes on a cobweb (Image credits: Luc Viatour/lucnix.be) (b) Scheme of the employed particle hopping model. Additional to normal diffusion, the asymmetry parameter p can be used to create directional flow mimicking drift of droplets.

References

[1] M.R. Evans, T. Hanney, S.N. Majumdar: *Spontaneous symmetry breaking in a one dimensional driven diffusive system*. Phys. Rev. Lett. **97**, 010602 (2006)

[2] B. Wacław, J. Sopik, W. Janke, H. Meyer-Ortmanns: *Tuning the shape of the condensate in spontaneous symmetry breaking*. Phys. Rev. Lett. **103**, 080602 (2009)

[3] J. Blaschke, T. Lapp, B. Hof, J. Vollmer: *Breath figures: Nucleation, growth, coalescence, and the size distribution of droplets*. Phys. Rev. Lett. **109**, 068701 (2012)