Tagged particle diffusion in single file systems

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Single file dynamics is a generic term for the dynamics of one dimensional systems in which neighboring particles cannot pass each other. A relation first proposed by Alexander and Pincus [1] connects the mean square displacement of a tagged particle in such a system to the time evolution of the collective density. In many cases this leads to a tagged particle mean square displacement proportional to the square root of the MSD of collective excitations; e.g. in the case of regular diffusion for the latter, the tagged particle MSD grows as $t^{1/2}$ with time. But in cases where collective excitations and tagged particle motion have different average drift velocities the tagged particle always exhibits regular diffusion about its average drift.

For hamiltonian systems with short ranged interactions the tagged particle MSD is dominated by a regular diffusion term proportional to t, due to sound mode contributions to the dynamics of the collective density (in other words, the Brillouin peaks). In addition there is a contribution increasing generically as $t^{3/5}$, due to the heat mode contribution (the Rayleigh peak).

Largely because of the one dimensional structure, finite size effects are strong. Taking these into account one finds very good agreement between theoretical predictions and computer simulations [2].

[1] S. Alexander and P. Pincus, Phys. Rev. B **18**, 2011 (1978).
[2] H. Posch, private communications.