Diffusion in the Cell Cytoplasm and Cell Nucleus

R. Hołyst

Institute of Physical Chemistry,
Polish Academy of Sciences,
ul. Kasprzaka 44/52, 01-234 Warszawa

The diffusion of molecules/particles in living cells and complex liquids does not agree with the Einstein's equation, often by many orders of magnitude. The equation relates the diffusion coefficient to the size of the diffusing object and the viscosity of the liquid. We corrected the Einstein formula and determined what we call length-scale dependent viscosity in cells/complex liquids. The diffusion in mammalian cell cytoplasm is largely unobstructed up to the scale of physical gel which is $\sim$ 100-150 nm (for HeLa cell). Above this scale, free diffusion across the cell is very strongly hindered. The diffusion in the cell's nucleus occurs in wide channels of size $\sim$ 150 nm, which percolate across the nucleus and occupy 1/3 of its volume. The viscosity in the channels is not much larger than the viscosity of water. Examples will be given for mammalian and bacteria cells. In bacteria cells, the viscosity very strongly depends on the length scale, changing from water viscosity at $\sim$ 1 nm scale to 10^4 times larger viscosity at $\sim$ 100 nm. Interestingly, the mammalian cell maintains the same nanoscale viscosity (probed by GFP) during the whole cell's cycle (36 h) including the division phase, despite dramatic changes in the cell's structure.