**Introduction**

Brownian motion originates from the observation of spontaneous movements of pollen grains in liquid, made in 1667 by the botanist Robert Brown. It is a physical description of the random motion of a particle immersed in a fluid. With arguments from statistical physics and kinetic theory of gases, this motion can be explained as the result of incessant collisions between the suspended particles and the surrounding fluid molecules. A quantitative description of the phenomenon was described by Einstein in 1905, then put into practice by Jean Perrin. The Brownian motion can be confined in a small area using a laser (optical tweezers). This technique was developed by Arthur Ashkin, and is very useful in microbiology, especially for moving or stretching particles.

**Brownian Motion**

Brownian motion is described by the Langevin equation:

\[
\frac{d\mathbf{v}(t)}{dt} = -\lambda\mathbf{v}(t) + \mathbf{f}(t)
\]

- \(\mathbf{v}\) : particle velocity
- \(\lambda\) : braking coefficient
- \(\mathbf{f}\) : rapidly fluctuating force (correspond to collisions with molecules of the fluid)

This equation can be solved to obtain the speed, but the main focus of this experiment will be to find the Diffusion Coefficient. For this, some transparent microspheres are put in water, under a microscope, and the trajectories are recorded. It is possible to see here some brownian trajectories for microspheres of radius \(a\approx2\mu m\) and \(a\approx3\mu m\). For larger particles, the motion becomes simpler.

Also, the mean square displacement \((\mathbf{R})^2\) can be used as an indication of particle deviation from its mean position over time. It is defined as:

\[(\mathbf{R})^2 = \langle (\mathbf{x}(t') - \mathbf{x}(t))^2 \rangle
\]

Now, according to Einstein’s theory, the mean square displacement described above corresponds to a diffusion process, and then:

\[(\mathbf{R})^2 = 2D \cdot t\]

- \(t\) : time
- \(D\) : diffusion coefficient

The theoretical diffusion coefficient \(D_{th}\) is known by solving Langevin’s equation (1).

\[
D_{th} = \frac{\kappa T}{6\pi\eta a}
\]

- \(\eta\) : viscosity of water
- \(\kappa\) : Boltzmann constant
- \(T\) : temperature

**Optical Trap**

The optical trap is formed using the light intensity, which is strong enough to hold a particle in place. The transparent nanoparticle is trapped, using the conservation of momentum and the refraction (Snell’s law) of the light rays coming from the laser.

Indeed, the light is more intense at the center of the laser beam. Thus, when the light rays are deflected, the total LIGHT MOMENTUM of the particle will be pointing down. Thus, the particle will stay on the axis of the laser.

Also, to avoid the particle moving on the axis of the laser, a lens is added. And with the same analysis, the particle will stay on a precise point of the laser’s axis.

**Conclusion**

The Brownian motion was observed. Larger particles have smaller Diffusion coefficient. The big particles almost not moved. The optical trap was performed. Due to some problem with the experiment and the focus of the laser, the effect was not very important, but it was still possible to see the particles stay in the laser beam radius.