<u>PLASMON – Exchange Grant – 4713</u>

Scientific Report of Exchange Visit (March 15th, April 12th 2015), F. Hajizadeh

Work title: "Optimized optical trapping of a gold nanorod in a live cell"

1- Purpose of the visit:

The main aim of this visit was to initiate a collaboration with the Single Molecule Optics group lead by Prof. Michel Orrit at the Leiden Institute of Physics, in the area of achieving a deeper optical potential for an optically trapped gold nanoparticle in complex environments, in particular live cells. The first step was to characterise the current optical tweezers setup at the host optical manipulation laboratory to achieve a better trapping efficiency while keeping heating to a minimum.

2- Description of the work carried out during the visit

As some recentreports in the host group show [1, 2], one single immobile plasmonic nanoparticle has crucial ability to enhance the single-molecule fluorescence. This valuable property could extend single-molecule studies to weakly emitting species. As a challenging goal, an optically trapped gold nanoparticle could provide a three-dimensional probe inside alive cell as a single-molecule detector. One initial issue in this direction is that the signal collected from the particle motion in the trap cannot be distinguished from thefluorescent dye's fluctuations. The main attempt of my work during this visit was to focus on characterizingthe three-dimensional optical trap quality and the frequency content of the particle motion in the trap in different media, which previously have been used to enhance the single-molecule florescence [1].

During my visit, I worked closely with one of the PhD student in the host group, Mr. Aquiles Carattino on an optical tweezers setup that has been developed and implemented at the host laboratory [3]. At first, we tried to check the alignment of the optical setup and we have made a change in laser diameter to achieve the optimal beam diameter for optical trapping [4]. We tried to trap a gold nanorod, 25nm×60nm in various environments (different mixtures of water and glycerol). We characterized the focus quality by forward scattering by the nanorod. The most reliable option to calibrate optical tweezersis its power spectrum, measured by means of a Quadrant Photo Diode (QPD), which provides high spatial resolution when mounted at the back-focal plane of the condenser lens. The trapping stiffness, which is proportional to a characteristic frequency named corner frequency, could be obtained by measuring this frequency [5]. The frequency content of the particle motion is related to the strength of the trap, for stronger optical trap, the high frequency components start to dominate the movement of the trapped particle.

Figure 1 shows the trapping corner frequency of a 25nm×60nm gold nano rod in water as a function of the depth, (distance from the surface of the cover slip). As shown in Fig.1, optical aberration of the oil immersion objective causes variations of the corner frequency and of the trapping stiffness as functions of the focusing depth. There is an optimal depth for trapping the nanorod, 10-15μm away from the cover slip.

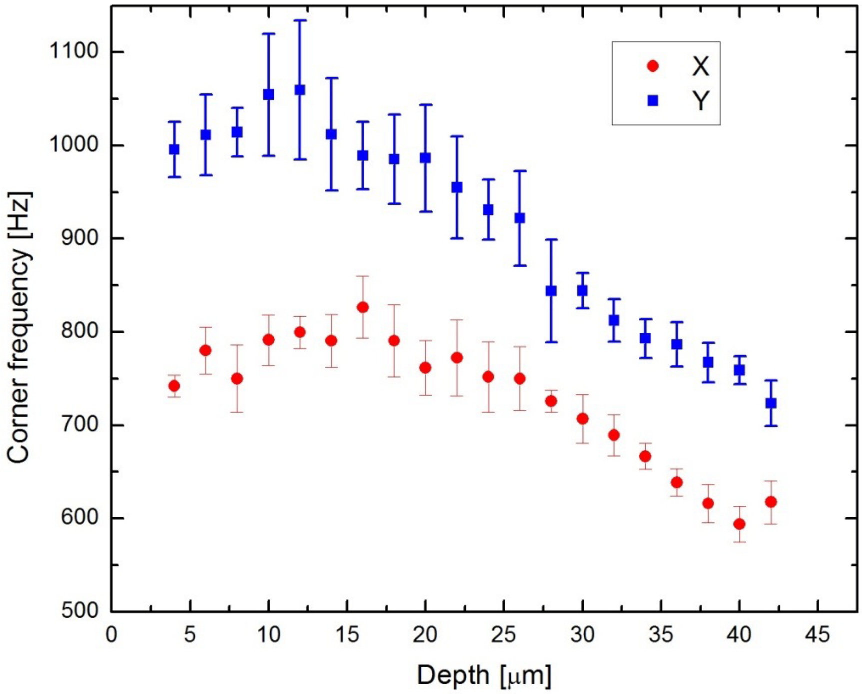

Figure1: Corner frequency of the optically trapped nanorod in two different lateral directions, as a function of the trap distance from the cover glass.

At the second step we tried to check the possibility of trapping in a viscous glycerol-water mixture. Due to the much slower dynamics of the rod trapped in glycerol, such viscous media are good candidates for fluorescence enhancement studies. Figure 2 shows a typical scattering image of a trapped gold nano rod in a 80:20 mixture of glycerol and water. We found that a gold nano rod could be stably trapped for a few minutes.

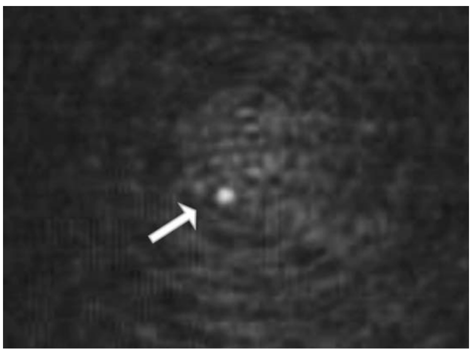

Figure 2: Scattering image of a trapped nanorod in 80:20 glycerol-water mixture.

We also tried to check the polarization effect of the trapping laser on the correlation time of the signal collected from a trapped particle.

References:

[1] H. Yuan, S. Khatua, P. Zijlstra, M. Yorulmaz, and M. Orrit, “Thousand-fold Enhancement of Single-Molecule Fluorescence Near a Single Gold Nanorod,” Angew. Chem. Int. Ed. 2013, 52, 1217

[2] S. Khatua, P. M. R. Paulo, H. Yuan, A. Gupta, P. Zijlstra, and M. Orrit, “Resonant Plasmonic Enhancement of Single-Molecule Fluorescence by Individual Gold Nanorods” ACS Nano, 2014, 8, 4440

[3] P. V. Ruijgrok,N. R. Verhart,P. Zijlstra,A. L. Tchebotareva, and M. Orrit, “Brownian Fluctuations and Heating of an Optically Aligned Gold Nanorod,” PRL 2011, 107, 03740

[4] A. Samadi and S.N.S Reihani, “Optical beam diameter for optical tweezers”, Opt. Lett. 2010, 35, 1494

[5] F. Hajizadeh and S.N.S. Reihani, “Optimized optical trapping of gold nanoparticles,” Opt. Exp. 2010, 18, 551

3- Description of the main results obtained

The duration of the project has been limited to 4 weeks, instead of requested 4 months. Because of the sort time, we mainly worked on

1- Optical alignment of the complex setup in the host laboratory,

2- Mounting and usage of QPD to investigate the trapping efficiency,

3- Investigation of the polarization effect on correlation time of the signal collected from a single trapped particle,

This project is in progressing by the PhD student, Mr. Aquiles Carattino.

4- Future collaboration with host institution (if applicable)

This visit to Prof. Michel Orrit’s lab, apart from offering me the possibility of getting introduced to advanced experimental techniques in fluorescence enhancements experiments, allowed me to have several scientific discussions with the members of the group, in connection with the field of optics at the nanoscale, which have led to some new ideas that will be studied further in a close future.

5- Projected publications / articles resulting or to result from the grant (ESF must be acknowledged in publications resulting from the grantee’s work in relation with the grant)

This project is ongoing, in case of any reporting of the results, ESF support will be acknowledged.

6- Other comments (if any)