Anderson localization of light in monodisperse TiO_2 nanospheres

Light scattering, disordered media, colloids, inorganic chemistry

The context

When waves diffuse through a random medium, the mean free path *l** is no longer the only length scale determining the physical situation. Due to interferences, additional effects will appear on the scale of the wavelength. A striking prediction made by Anderson in 1958 [1] is that diffusion should come to a halt in a medium where *l** is comparable with the wavelength. In the context of electronic systems, this has been used as an explanation for the metal insulator transition when impurities are present.

Until now, localization of light has still not been observed because the measured samples did not scatter enough (*l** too large). We try to observe Anderson localization in a system made of roughly wavelength size particles with a high refractive index (rutile TiO_2, n=2.7) surrounded by air. The reason is that the scattering strength increases with the refracting index difference between the scatterers and the surrounding medium. We measure the dynamic transport by sending a femtosecond pulse of visible light in the sample and measuring the transmitted intensity as a function of time on the other side (time of flight, fig. 1). Without localization, diffusion theory predicts how the light wave should propagate, and experiments are in very good agreement with it. Localization should manifest itself by deviations from this well established diffusion theory.

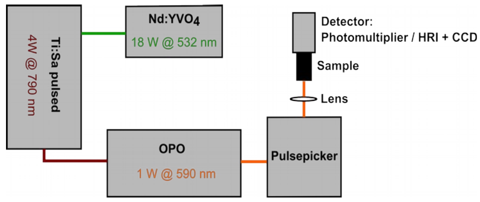

Figure 1: *Time of flight setup.* (Lukas Schertel)

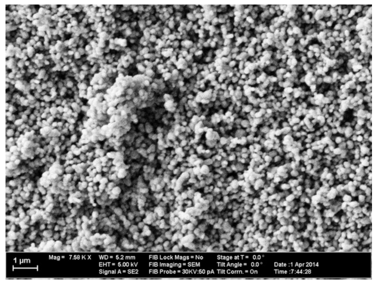

Figure 2: *Scanning electron microscope of TiO_2 powder (Dupont R700).* (Lukas Schertel)

Our actual samples are commercial TiO_2 nano particles usually used in white paint (fig. 2). They have an irregular shape and are strongly polydisperse (25% to 50%). To improve the scattering strength, we would like to better control the shape and the size of these particles in order to hit Mie resonances of monodisperse TiO_2 particle (fig. 3). To our knowledge, such high refractive index colloidal glasses have never been studied. Among others, a promising method for the synthesis is to use titanium glycolate ($TiGly_2$) as a precursor for the nucleation of monodisperse spherical $TiGly_2$ colloids ([3], fig. 4). These colloids can then be converted into rutile TiO_2 by heating the samples.

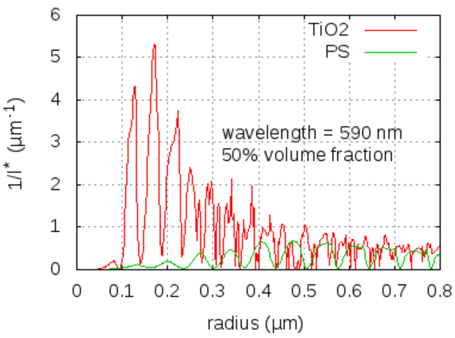

Figure 3: *theoretical predictions for 1/l* ("scattering strength") of a monodisperse multiple scattering sample as a function of the particles radius made of TiO_2 (n=2.7) or polystyrene (PS, n=1.6). The model is further described in [2].*

The project

In this internship, you will be involved as well in the synthesis of the samples, in cooperation with the inorganic functional materials group of Sebastian Polarz [4], as in the characterization by advanced optical methods developed in our group (time of flight of photons, coherent backscattering).

Interested?

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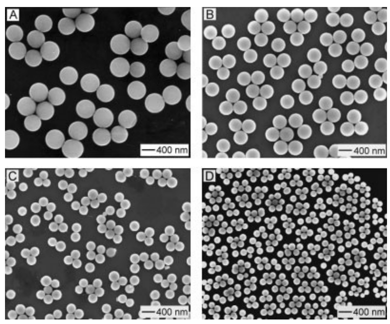

Figure 4: *SEM images of spherical titania glycolate colloids (image taken from [3]).*

[1] P.W. Anderson, *Phys. Rev.* **109**, 1492 (1958)
[2] R. Tweer, Vielfachstreuung von Licht in Systemen dicht gepackter Mie-Streuer: Auf dem Weg zur Anderson-Lokalisierung?, PhD Thesis, Universität Konstanz (2002)
[3] X. Jiang *et al.*, *Adv. Mater.* **15**, 1205 (2003)
[4] AG Polarz, website: http://cms.uni-konstanz.de/polarz/