Quantum sensing of microparticle charges in plasmas

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Electrical charge is an important parameter of dust particles immersed in plasmas. It enters into practically all dust-related quantities. In laboratory experiments, the charge is usually measured by means of dynamical methods. Such methods have obvious disadvantages. It is, therefore, very important to develop optical methods of the charge measurements.

We propose to use the quantum dots (QDs) deposited on the surface of the microparticles as optical charge sensors [1]. Radiative transitions of the QDs are subject to the so-called quantum-confined Stark effect [2], for which the spectral shift of the photoluminescence wavelength is proportional to the square of the local electric field. Experiments with QDs deposited on large flat plasma-facing surfaces proved the sensitivity of the QDs to the surface charge [3].

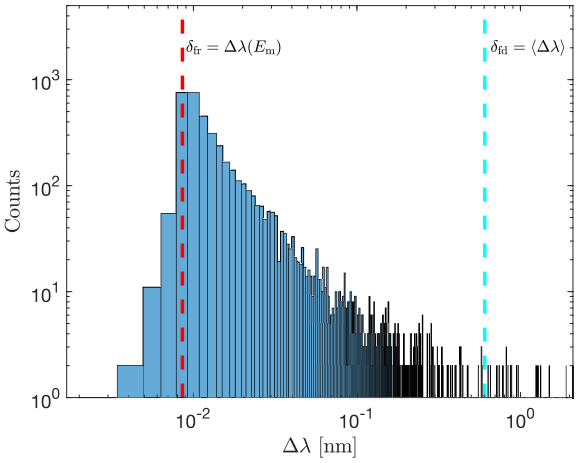

Figure 1: *Statistics of the Stark shift for a CdSe QD of* 3.3 *nm radius on the surface of a microparticle of* 4.6 µm *radius and charge of* 3×10^4 *elementary charges.*

As calculations show, the electric field sensed by a QD (and the respective Stark shift) will be subject to large fluctuations (see Figure 1). The value of the Stark shift is of the order of fractions of nm and, therefore, should be accessible for measurement.

Other issues related to the possible experimental realization of such measurement (heating of microparticles and QDs, sputtering of QDs, surface design) will be discussed.

References

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