

In this seminar, I will present research conducted over the past six years on active biological matter, comprising of externally activated and intrinsically active biological matter. Over the course of my PhD and first post-doctoral role, I studied higher-order field-particle interactions in the dielectrophoresis (DEP) of non-spherical biological particles. DEP has established its status as a versatile technique for characterization, as well as separation and manipulation of micron and sub-micron bioparticles, with applications including the separation of cancerous from healthy blood cells, and the realization of the variety of reactions that take place on miniature devices known as lab-on-a-chip, where multiple bio-/chemical processes currently performed in huge laboratories are integrated on a small chip with improved accuracy, increased speed, and substantially reduced reagent cost, delivering the prospect of point-of-care diagnosis. It came to our attention at the onset of the project that the conventional DEP theory, accounting for only the dipole moment of bioparticles, is becoming increasingly unreliable for predicting the electrical force as electrode structures verge toward smaller dimensions (nano-electrodes). Also, and related to this simplifying approximation, all modelling was based on a spherical approximation for (mostly highly) non-spherical particles, e.g. the red blood cell. A novel method was developed and implemented with verification using the unassailable Maxwell stress tensor method, that enables accurate determination of the DEP force (and hence accurate characterization of bioparticle properties, essential in medical diagnosis) by accounting for multipolar terms of the force and by setting no restriction on particle or electric field geometry. The development of the method, the quantified importance of multipolar contributions to the DEP force - particularly on the many non spherical bioparticles - and the generality of the method, namely its application to dielectric characterization in the general sense, will be discussed.

In the second, and considerably shorter, part of the seminar, I will present my research at a second postdoctoral role on modelling biofilm development in the upper respiratory tract. In close collaboration with life scientists, I developed a model of bacterial growth in the human body in the adherent form known as biofilms and came to new findings on the much-debated and medically-relevant issue of antibiotic resistance which has rendered the biofilms a common cause of persistent infections. Experimental and simulation results, the expanse room for further work, and how the phenomena relate to other important areas of active research in physics, will be discussed under both topics. The seminar can be summarized as modelling the physics underlying beneficially and adversely active biological matter, which is the area I am hoping to delve deeper into over the coming years of my career.