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Anisotropic Spiky Colloids for Antifouling Surfaces

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Project Title
Anisotropic Spiky Colloids for Antifouling Surfaces

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I. Project Description
Contaminated surfaces due to the adhesion of external organisms at different scales are a major cause of contamination of biological devices and the efficiency reduction in maritime applications. However, a counteract fouling effect at bigger scales might increases the fouling at smaller scales, which is influenced by the topography and the environmental conditions. Assembling anisotropic spiky colloids with different shapes is an innovative approach to fabricating antifouling surfaces to repel multiple-scale inserts. Manufacturing antifouling surfaces requires direct quantification and modeling of the interactions of the spiky particles with substrates and between particles as a function of position and orientation. However, one of the main challenges in colloid science is quantitatively describing the multiple degrees of freedom of anisotropic particles and their interactions in the position and orientational spaces.

This project aims to assemble periodic spiky structures composed of spiky particles able to repel multi-scale inserts at different flow field conditions. We will analyze suspensions composed of interacting spiky particles with different spike morphology and distribution using unit quaternion parameters, which are advantageous with respect to Euler angles since they provide a singularity-free representation of the relative orientations between particles, and they are not susceptible to the Gimbal lock. Furthermore, we will implement our developed expressions for the extended Surface Element Integration (SEI) method to quantify the DLVO (named after Derjaguin, Landau, Verwey, and Overbeek) interactions between an arbitrary anisotropic particle with a surface as a function of position and orientation. DLVO interactions for spiky particles require a methodology able to describe the behavior of surfaces with zero and infinite Gaussian curvatures as a function of position and orientation, such as those with a sharp corners and flat surfaces represented by superellipsoids. The extended SEI method provides a singularity-free algorithm to calculate DLVO interaction in particle shapes with sharp corners and flat walls compared with the Derjaguin approximation. Then we will apply this novel extended SSEI approach to quantify the interaction forces and torques between spiky particles. We expect this fundamental research will provide a rational framework to advance novel applications, such as antifouling surfaces due to orientable and shape dependence of the adhesion on spiky surfaces.

II. Student Duties, Contributions, and Outcomes

a. Specific Student Duties
The student must perform the numerical simulations, plot the results, analyze the data, and write reports on a regular basis during the summer. For that purpose, the student will have a computer station where to perform the simulations and a hard drive to store/backup the data. Additionally, the student must review the current literature in the field regularly under the guidance of the Professor and the graduate students. Furthermore, the student will present his/her results three times during the summer in group meetings. It is expected to submit two reports during his/her stay during the summer, a midterm report, and a final report.

b. Tangible Contributions by the Student to the Project (10% of Review)
It is expected that the student publishes his/her final results in Perpetua, and present his/her results in the poster session during the fall at UAH. The extended version of the final report, in collaboration with the graduate student and under the supervision of the Faculty, will be published in a peer-review Journal.

c. **Specific Outcomes Provided by the Project to the Student** (30% of Review)

The student will learn how to solve a two-dimensional stochastic equation between anisotropic objects as a function of position and orientation. The student will learn computational tools (e.g., Unix/Linux, Matlab, Fortran, and Wolfram Mathematica) relevant for different computational research work. Additionally, the student will learn important concepts about translational and rotational Brownian motion of colloidal particles and how to model the time required to control the arrangement between them. The student will learn how to analyze, plot, and calculate the mean-passage-time of a two-dimensional energy landscape. The student will work in a research environment, participating in research discussions, and collaborating with graduate students for writing a peer review article. The interaction with other graduate students will be a valuable experience for future undergrad or graduate research experiences.

**III. Student Selection Criteria**

This project is open to highly motivated students at all academic ranks from the college of Sciences and the College of Engineering.

**IV. Project Mentorship** (30% of Review)

The Professor will train the student daily during the first two weeks (or longer) of the project to ensure the student learns and handles the computational tools required to accomplish the project. After that, the student will meet the Professor every other day to present one or two slides about his/her research results achieved during the previous days. The Professor will advise the next steps in the research to be accomplished before the next meeting, i.e., the Professor will ensure the student success in the undergraduate summer project with permanent guidance as to any other graduate student. Additionally, the daily informal conversations with the Professor every time that he steps in the laboratory or the undergraduate student requires it to overcome any research problem. Furthermore, the student will interact with a Ph.D. student and a Master's student while the research project is completed. Fully trained graduate students will be the first contact persons in the computational laboratory to answer his/her questions related to the research topic.