Abstract

There has been a surge of interest in recent years to design and fabricate various types of motile micro/nanoparticles that can be maneuverer using chemical, optical, thermal, electrical or magnetic energy sources. A collection of such motile particles can be used as a model system to study various active matter phenomena, which can answer fundamental questions related to non-equilibrium statistical physics. This motile micro/Nano system can also be important in various biomedical applications like targeted drug delivery, microsurgery, biochemical sensing and disease diagnosis. Among several actuation schemes, magnetic actuation deserves a special mention owing to its non-invasive and non-chemical mode. In this thesis, micron sized helical structures have been fabricated, which are rendered magnetic by a thin coating of magnetic materials and actuated by rotating field. Using this system, a study on generalized dynamics of elongated structures has been done, which is also supported by analytical theory and numerical calculations. Both experiments and numerical simulations show the existence of multiple cut-off frequencies related to the stability of deferent dynamical modes of an elongated structure, whose analytical expressions have been derived in the present work. Despite the observation of rich dynamical comigrations, the field dependent directionality of this mode of actuation by rotating field fails to qualify the experimental system as active matter, thus hinders the possibility of using it as a model system to study a wide variety of phenomena like pattern formation in swarm motion, synchronization, etc. In this thesis, a deferent actuation technique has been demonstrated, which decouples the directionality from the applied external field, thus enabling the helical micro swimmers to propel in any direction. The system presented here is the rest experimental demonstration of magnetically actuated active matter system, where the helical structures show back and forth motion in a random direction, thus resembling a reciprocal swimmer and shows enhanced disutility in accordance to earlier theoretical predictions. We further extended this idea to report how the same actuating field used for reciprocal motion can be tuned to break the temporal symmetry to design a non-reciprocal swimmer. The actuation principle is based on the idea of `Brownian Motor', where the reciprocity is broken using asymmetric field pattern and incorporating thermal actuations into the system. A detailed numerical study of the dynamics of the system is reported here which sets the criteria to build a system with optimal performance where tuning from reciprocal to non-reciprocal actuation can be achieved in a simple manner. In a related project, we report an actuation scheme to manoeuvre geometrically identical nanostructures in deferent directions, and subsequently position them at arbitrary locations with respect to each other. In comparison to the other techniques where controlling the directionality and actuation are powered by separate energy sources, the experiment reported here shows how these two factors can be controlled only by magnetic fields. The technique shown here requires proximity of the nanostructures to a solid surface and is applicable for independent positioning of any number of micro/nanobots; thus, can be useful in applications that require remote and independent control over individual components in microlidar environments. Finally, we report couple of experimental techniques to study the hydrodynamic interactions between helical swimmers. In one of the techniques, we investigate possibility of synchronization between two rotating helical swimmers at low Reynolds number conditions. In the other technique, we discuss deferent ways to study motion of a collection of magnetically actuated helical swimmers. The methods presented here show deferent fabrication schemes that are useful to avoid magnetic agglomeration. The preliminary experiments reported here can be useful to study the behaviour of a collection of magnetic swimmers coupled via hydrodynamic interactions.