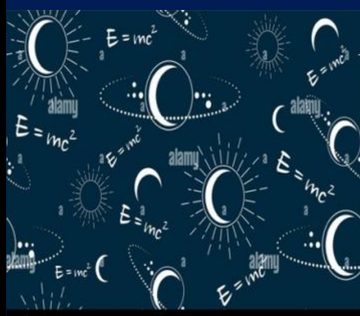
భారతీయ సాంకేతిక విజ్ఞాన సంస్థ హైదరాబాద్
भारतीय प्रौद्योगिकी संस्थान हैदराबाद
Indian Institute of Technology Hyderabad

Engineering Science



PhD Brochure

భారతీయ సాంకేతిక విజ్ఞాన సంస్థ హైదరాబాద్
भारतीय प्रौद्योगिकी संस्थान हैदराबाद
Indian Institute of Technology Hyderabad

Department of Engineering Science

Entering a PhD program in Engineering Science typically requires a strong foundation in fundamental science and engineering principles, along with a passion for research and innovation. Here's a general outline of what you can expect:

1. **Preparation:** Before applying, ensure you have a strong academic background, usually with a Bachelor's and Master's degree in engineering/science or a closely related field. Your undergraduate and/or graduate GPA should be competitive.
2. **Research Experience:** We prefer candidates with research experience. This can include working on research projects as an undergraduate or a master's student, internships, or relevant work experience in industry.
3. **Recommendation Letters:** Strong recommendation letters from professors or supervisors who can attest to your research capabilities and potential are crucial. These letters should highlight your academic achievements, research skills.
4. **Statement of Purpose:** Your statement of purpose should articulate your research interests, career goals, and why you're interested in pursuing a PhD in Engineering Science at IITH. Be sure to align your interests with the research focus of the faculty driven projects which are appended below.
5. **Interviews:** We may require exam/interviews as part of the application process. This is an opportunity for the admissions committee to learn more about you and your research interests, as well as for you to ask questions about the program and faculty.
6. **Funding:** Our PhD programs offer financial support to admitted students in the form of stipends according to MoE norms.
7. **Application Deadlines:** Be mindful of application deadlines and submit your materials well in advance. Deadlines are available in the IITH Acad website.
8. **Selectivity:** PhD program in Engineering Science are often highly competitive, so be prepared for a rigorous selection process.

The following are the courses offered by Engineering Science Department

B.Tech. in Engineering Science at IIT Hyderabad is a unique program being offered for the first time in India. It opens the doors to different specializations and provides a holistic engineering education. The basic structure is as follows: for the first 2 years (4 semesters) the student does basic courses in Mathematics, Physics, Chemistry, and different fields of engineering. In the last 2 years (4 semesters) the student then specializes in any field of his / her choice -- specialization is completely open: It could be any branch of engineering -- The final degree will read: **B.Tech. in Engineering Science and Specialisation in XXX**.
"This program is in tune with what the industry is demanding today. They would like students to be educated with what they call as a 'T' education.."

Engineering Science Faculty

Dr. Bhuvanesh Ramakrishna

Associate Professor & Head of the Department

Areas of Interest :
Intense Laser Plasma Interaction, Ion acceleration, Fast Ignition Fusion.

Email : head@es.iith.ac.in

VIEW PROFILE

Dr. Abhinav Kumar

Associate Professor

Areas of Interest :
Wireless communications and networking, green cellular networks, user network selection, device to device communications, and radio resource management in heterogeneous wireless access networks.

Email : abhinavkumar@iith.ac.in

VIEW PROFILE

Dr. Kaushik Nayak

Associate Professor

Areas of Interest :
Electron Devices Physics, Mesoscopic Electronics, and Carrier Transport Phenomena.

Email : knayak@ee.iith.ac.in

Dr. Aiyappan Srinivasan

Associate Professor

Areas of Interest :
PDE and Homogenization.

Email : aiyappan@math.iith.ac.in

Dr. Anurup Dutta

Associate Professor

Areas of Interest :
Process monitoring of manufacturing processes, laser based micro and nano-manufacturing and applications of subwavelength laser spot using nanoscale optical antenna.

Email : anurup.datta@mae.iith.ac.in

Dr. Prakhar Gupta

Assistant Professor

Areas of Interest :
Multiscale and multiphysics modeling, computational materials science, nonlinear elasticity, biomechanics, computational mechanics.

Dr. Digvijay S Pawar

Assistant Professor

Areas of Interest :
Driver and Pedestrian Behavioral Modeling, Traffic Safety and Accident Analysis, Traffic Operation and Simulation, Intelligent Transportation Systems, Statistical Modelling and Classification Techniques, Human factors

Email : dspawar@iith.ac.in

VIEW PROFILE

Dr. Munwar Basha

Associate Professor

Areas of Interest :
Municipal Solid Waste Landfills, Computational Geomechanics, Unsaturated Soil Mechanics, Reliability-Based Designs in Geotechnical & Geoenvironmental Engineering, Soil Dynamics and Earthquake Resistant Design of Retaining Structures, Rock Mechanics, Reliability analysis of pavement Geotechnics.

Email : basha@iith.ac.in

VIEW PROFILE

Dr. Karteek Sreenivasaiah

Assistant Professor

Areas of Interest :
Theoretical Computer Science, Computational Complexity.

Email : karteek@cse.iith.ac.in

VIEW PROFILE

Dr. Neeraj Kumar

Assistant Professor

Areas of Interest :
Sensorimotor Learning, Motor Memory Consolidation, Stroke Rehabilitation, and Brain stimulation.

Email : neeraj.kumar@la.iith.ac.in

VIEW PROFILE

Dr. Praveen Meduri

Associate Professor

Areas of Interest :
Photoelectrochemical water splitting, Solar fuels, Metal-ion/metal-sulfur/metal-selenide batteries, Carbon sequestration.

Email : meduripraveen@che.iith.ac.in

VIEW PROFILE

Dr Himanshu Joshi

Associate Professor

Areas of Interest :
Computational Biophysics, DNA nanotechnology, Nanopores, Membrane-DNA interactions, Synthetic molecular systems, Biomimetic channels for selective transport of water and ions, Computational virology.

Email : hjoshi@bt.iith.ac.in

VIEW PROFILE

Dr. Venkata Rao Kotagiri

Assistant Professor

Areas of Interest :
Functional Organic Materials and Supramolecular Chemistry.

Email : kvrao@chy.iith.ac.in

VIEW PROFILE

Dr. Chandrasekhar Murapaka

Assistant Professor

Areas of Interest :
Spintronic based memory and logic devices, Nanomagnetic materials,Domain wall dynamics in ferromagnetic networks,Spin torque nano-oscillators for RF applications,Spin-orbit torque induced magnetization switching and dynamics,Magnetic tunnel junctions, Micro and Nanofabrication techniques

Email : mchandrasekhar@iith.ac.in

VIEW PROFILE

Dr. Aravind Kumar Rengan

Assistant Professor

Areas of Interest :
Nanomedicine, Cancer Nanotechnology, Photothermal Therapy, AMR, Biomaterials, Drug Delivery, Proton Beam Therapy.

Email : aravind@bme.iith.ac.in

VIEW PROFILE

Dr. Manish Singh

Assistant Professor

Areas of Interest :
Databases, Data Mining, HCI, Information Retrieval, Information Visualization

Email : msingh@cse.iith.ac.in

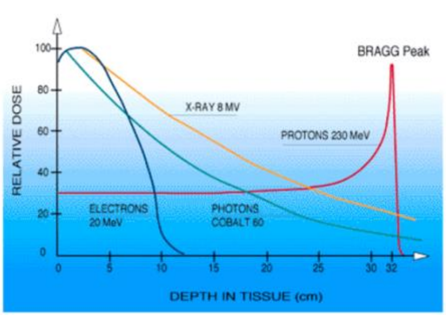
VIEW PROFILE

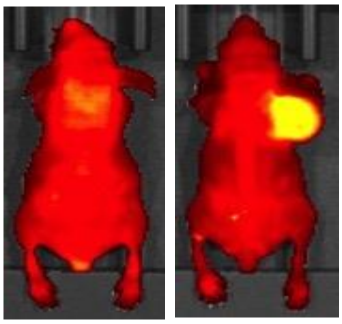
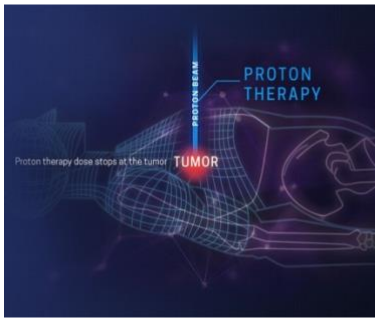
Interdisciplinary PhD projects are research endeavours that span multiple academic disciplines, combining methodologies, theories, and perspectives from different fields to address complex problems. These projects are becoming increasingly common as many contemporary issues cannot be adequately addressed within the confines of a single discipline. Interdisciplinary research offers a more holistic approach, drawing on diverse knowledge bases to gain new insights and solutions. Interdisciplinary PhD projects offer unique challenges and opportunities, requiring students to communicate across disciplinary boundaries, synthesize diverse bodies of knowledge, and develop innovative approaches to complex problems. They can also lead to impactful research outcomes with real-world applications and contribute to the advancement of knowledge in multiple fields. The following projects will give a brief overview of the expertise available in the Department. Students may choose to opt any of the following topic of their choice for PhD.

1. *Laser driven Compact Ion based Nanotheranostics for Cancer Treatment*

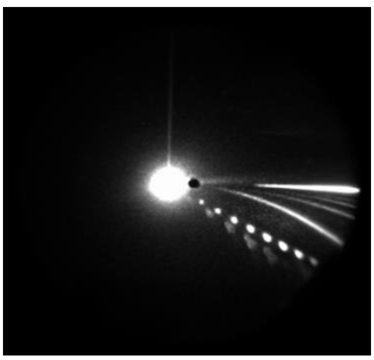
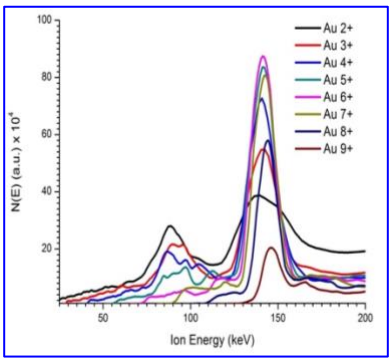
(Drs Bhuvanesh Ramakrishna and Aravind Kumar Rengan)

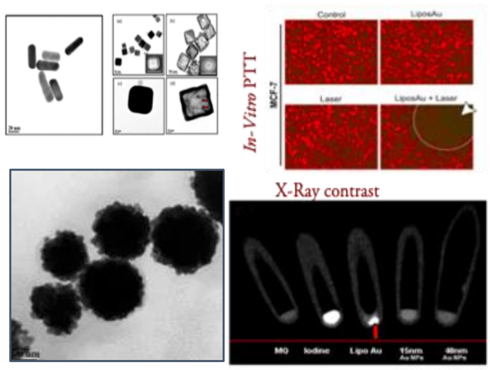
The interaction of intense laser pulses with matter is opening up new frontiers in physics via the production of extreme pressures, temperatures and intense electric and magnetic fields. This is leading to the use of high power laser radiation for exploring the properties of hot dense matter, the production of high-energy particles and radiation and the development of schemes for “table top ion acceleration”. These advances are driven by rapid developments in ultrashort pulse laser technology, which have enabled new regimes in laser power and intensity to be reached. The principal aims of this proposed project are to investigate the usefulness of employing laser driven ion beams for “cancer therapy”. This would provide possibilities of better dose conformity to the treatment target when compared to commonly used photon or electron beams. Proton beams have low entrance dose, sharp penumbra, rapid fall off at the distal edge of the dose distribution, and the maximum rate of energy loss at the end of the range, i.e. the Bragg peak effect. Nanoprobes that act as sensitizers would be deployed to enhance the theranostic effect of the laser driven compact ion therapy.



Recent Results: Acceleration of gold ions to 100 KeV from a Table top Laser. Organo-Inorganic hybrid nanosystems (developed in-house) are being explored for theranostics of cancer.

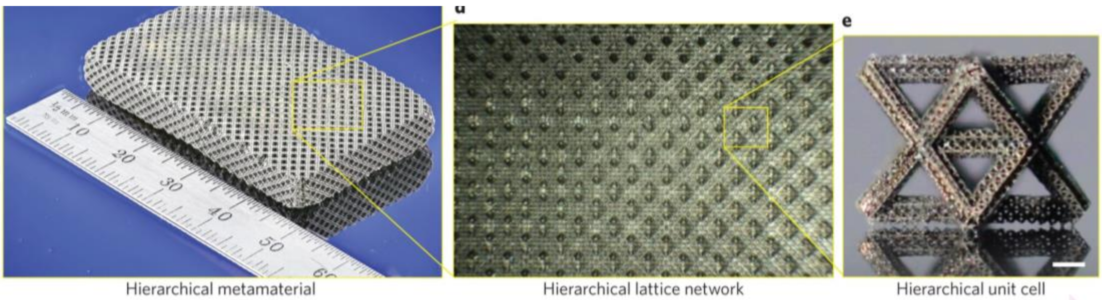


Physical Review E 92 (5), 051103
Physics of Plasmas 25 (12), 123102
Matt er and Radiation at Extremes 5 (4), 045402
Nanoscale 14 (25), 9112
ACS Materials Letters 5 (10), 2726

2. DAMM: Designing Advanced Mesoscale Metamaterials

(Dr. Prakhar Gupta and Dr. Anurup Datta)

In this project, we will explore the design and fabrication of lightweight mesoscale metamaterials, focusing on their unique properties and potential applications. By manipulating the structure and composition at the mesoscale, novel materials with tailored mechanical properties will be created. Applications span various fields, including aerospace, robotics, biomedical engineering, and telecommunications. Mesoscale metamaterials offer opportunities for lightweight structures with enhanced strength, vibration damping, and electromagnetic shielding capabilities. Through a combination of advanced mathematics, mechanics, design techniques and precise fabrication methods, this research contributes to the development of innovative materials with diverse practical applications. We are looking for students who are having a deep interest in mathematics and mechanics.



Zheng, X., Smith, W., Jackson, J., Moran, B., Cui, H., Chen, D., Ye, J., Fang, N., Rodriguez, N., Weisgraber, T. and Spadaccini, C.M., 2016. Multiscale metallic metamaterials. *Nature materials*, *15*(10), pp.1100-1106.

3. Utilizing Data-Driven Car-Following Models for V2X-Enabled Intelligent Transportation System

(**Dr. Abhinav Kumar and Dr. Digvijay S. Pawar)**

Traffic accidents and congestion pose significant challenges for transportation systems. Advancements in technology offer promise for addressing these issues effectively. Intelligent Transportation System (ITS) technologies, such as Vehicle-to-Everything (V2X), have seen rapid development recently. Current V2X deployments encompass Dedicated Short-Range Communication (DSRC) and Cellular Network-based technologies like C–V2X. These systems enable vehicles to exchange data with other elements in the transportation network, laying the groundwork for smarter solutions. V2X has shown potential in mitigating accidents, congestion, and pollution.
The integration of V2X has transformed the traffic environment by providing vast amounts of real-time information to drivers and vehicles. This information serves as a basis for decision-making, potentially optimizing car-following behaviour and improving traffic flow dynamics. However, traditional car-following models lack the capability to describe behaviour in V2X environments accurately. Consequently, this proposal aims to utilize a data driven approach to develop car-following models specific to the V2X environment. These objectives aim to enhance our understanding of how V2X technology influences car-following behaviour and traffic flow dynamics, ultimately contributing to the development of more efficient and sustainable transportation systems.

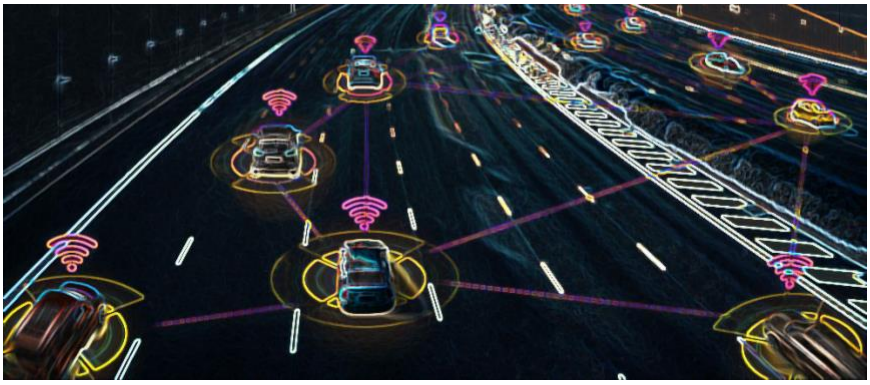


Figure: V2X-Enabled Transportation Systems

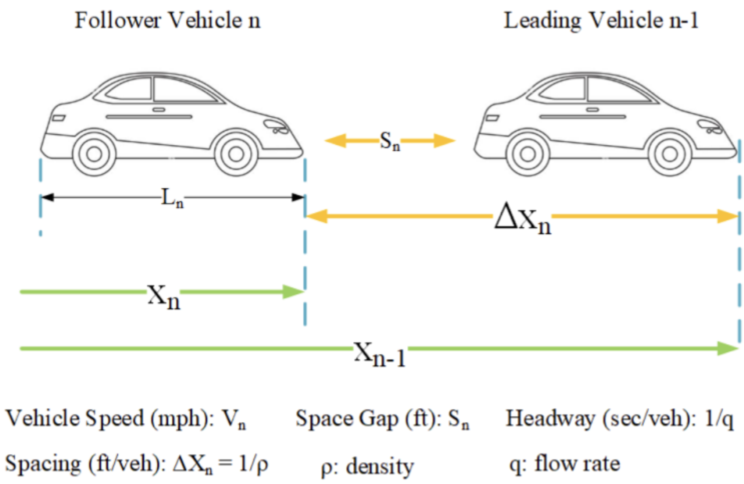


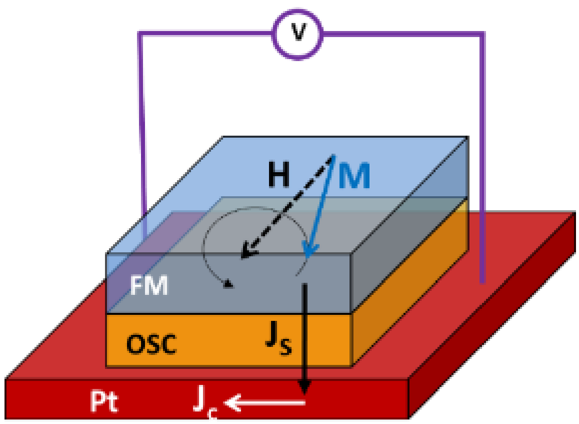
Fig. Car-Following and Microscopic Traffic Flow Properties
(https://arxiv.org/pdf/2304.07143.pdf)

4. Organic spintronics: spin injection and transport at molecular spinterface

Dr. Venkata Rao Kotagiri and Dr. Chandrasekhar Murapaka

Spin orbit coupling (SOC) – a well-known but less explored until recently, has opened up new paradigm for controlling spintronic devices and a new frontier has been established as spin-orbitronics. In a SOC based device, the interface plays a crucial role. Typically, a ferromagnet (FM)/non-magnetic (NM) bilayer structure is used to explore novel properties like spin pumping (SP) and inverse spin Hall effect (ISHE) which are associated with the SOC. The choice of the NM layer is typically a heavy metal (inorganic) with large SOC strength. However, some of the major drawbacks of such FM/NM (inorganic) devices include small spin diffusion length (few nm) and short spin relaxation time (ns) which hinder practical realizations of these structures in a pure spin current spintronic device.

A totally new avenue of interface spintronics is FM/NM heterostructures where the NM layer is made from organic semiconductors (OSCs). It is believed that this novel interface manifests spin-dependent density of states due to interactions and hybridizations of organic molecules with the FM layer [M. Cinchetti et al., *Nature Mater* 16, 507–515 (2017)]. Such FM/OSC interface is termed as 'spinterface'. Moreover, relatively low SOC of OSCs offers a pathway to improve spin diffusion length and spin relaxation time by several orders. Importantly, organic spinterface is gaining momentum due to the observations of long spin diffusion length (hundreds of nanometers) and spin relaxation time (hundreds of microseconds) [Wang et al. *Nat. Electron.* 2, 98–107, (2019)]. Furthermore, the possibility of low-cost large-scale production and tunable chemical functionality of organic layer are added advantages for FM/organic heterostructures. Such functionalities are inaccessible in conventional FM/NM (inorganic) devices. Recently, spin mixing conductance ($g_{\downarrow\uparrow}$) – a parameter which determines the efficiency of spin current generation is found to have significantly large values. In this proposal, we would like to harness pure spin current in novel FM/organic interface by using an emerging class of two dimensional (2D) conjugated polymers which possess high charge carrier mobility and crystalline order. We aim to engineer molecular structures and their compositions at the interface in order to optimize the performance for pure spin current generation. The primary experiments include precise measurements of SP and ISHE in such heterostructures.



Related publications from our group:

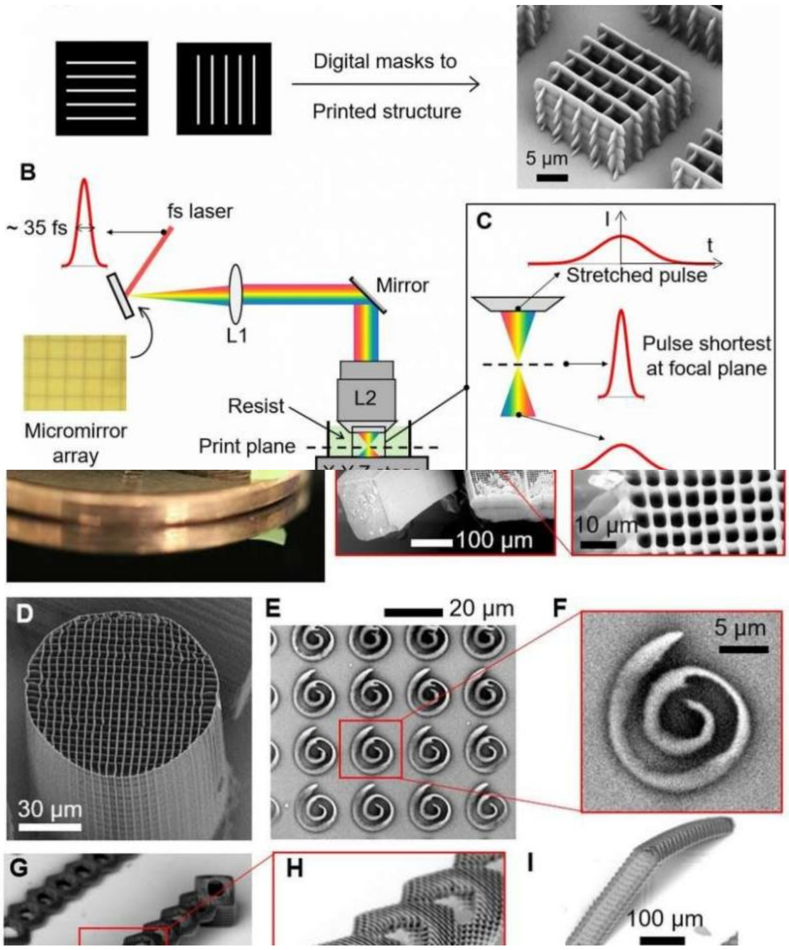
1. R Gupta et al., "*Chemical Approach Towards Broadband Spintronics on Nanoscale Pyrene Films*", Angewandte Chemie, e202307458 (2023).

2. Talluri Manoj, et al., "*Giant Spin Pumping at Ferromagnet (Permalloy) - Organic Semiconductor (Perylene diimide) Interface*", RSC Advances 11, 35567 (2021).

5. Femtosecond Laser based Additive manufacturing

Dr. Anurup Datta and Dr. Bhuvanesh Ramakrishna

Ultrafast laser-based additive manufacturing, often referred to as ultrafast laser 3D printing or simply ultrafast 3D printing, is an advanced manufacturing technique that utilizes ultrafast lasers to build three-dimensional structures layer by layer. Unlike traditional 3D printing methods that use thermal processes or extrusion techniques, ultrafast laser-based additive manufacturing relies on precise and rapid bursts of laser energy to selectively solidify or ablate material in a layer-by-layer fashion. Ultrafast lasers enable extremely precise control over the material processing, leading to high-resolution prints with intricate details and fine surface finishes. The short pulse durations of ultrafast lasers (typically in the femtosecond range) allow for minimal heat diffusion and reduced thermal damage to the surrounding material, resulting in high-quality prints. Continuous advancements in laser technology, materials science, and process optimization techniques are driving improvements in the speed, efficiency, and cost-effectiveness of ultrafast laser-based additive manufacturing systems. Research efforts are focused on enhancing build rates, reducing material waste, and expanding the range of printable materials. Overall, ultrafast laser-based additive manufacturing holds great promise for revolutionizing manufacturing processes by offering unparalleled precision, speed, and versatility in the fabrication of complex 3D structures across various industries.



Opt. Express **2005**, *13*, 4708–4716
Appl. Phys. A **2016**, *122*, 1–8

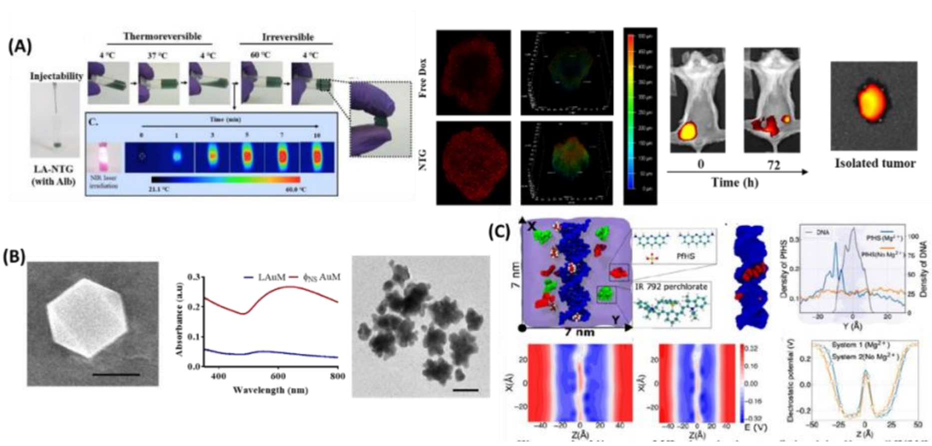
6. Physics based multiscale modelling and simulations to decipher the interaction between nanoparticle and cancer cells for efficient therapeutics.

Dr. Himanshu Joshi (BT) and Dr. Aravind Kumar Rengan (BME)

Nanotechnology has emerged as an increasingly promising and cost-effective field, particularly in cancer theranostics, attributable to the distinct physico-chemical properties exhibited by nanoparticles compared to their bulk counterparts. Researchers have extensively explored various nanomaterials tailored for targeted and sustained drug delivery, often integrating multiple treatment modalities into a single platform to achieve synergistic effects. Moreover, nanomaterials offer the advantage of selectively accumulating in tumor cells over normal cells, primarily through the enhanced permeation and retention effect facilitated by the compromised lymphatics and vasculature characteristic of cancer cells. Despite the growing interest of in the usage of nanomaterials for cancer theranostics, their full potential in combating tumors is yet to be explored. Theoretical and computational studies could help in rationally designing these nanotherapeutics by understanding the molecular level interaction between the nanomaterial and biological matter in a cellular like environment. Due to the rapid advancement in computer architecture, methods in molecular modeling and machine learning, molecular dynamics (MD) simulation has become a powerful tool to reveal insights into the intricate molecular-level interactions between nanoparticles and cancer cells. These simulations aid in the meticulous design and optimization of nanoparticles for targeted drug delivery to cancer cells, as well as in comprehending the dynamics of cellular interactions, internalization mechanisms, and predicting the toxicological profiles of developed nanosystems.

The principal aim of this proposed project is to develop a robust computational framework to understand the interaction of nanomaterials with proteins and lipid assemblies using multiscale modeling approaches. We plan to build on *ab-initio* DFT calculations, QM/MM, all-atom and coarse-grain MD simulations, and continuum Navier–Stokes equations. The machine learning-based force-fields potentials will be integrated to improve the accuracy of all-atom MD simulations. Information deduced from simulation trajectories and analysis will be used to understand the binding mechanisms which is expected to help in rationally designing experiments, understanding the experimental outcome, and prospective clinical trials.

Recent Results: (A) Lipo-polymeric hydrogel, (B) Gold coated phage nanosomes being developed are explored for cancer theranostic applications (C) MD simulation depicting interaction of intercalating dye and drug to DNA based nanomatrix



Advanced Therapeutics. 18:2300345. ACS Macro Letters, 12, 255. ACS Nano. 10 (8), 7780. Nature nanotechnology 15 (1), 73. Nucleic Acid Research 46 (5), 2234.