Course title	Selected research topics at ICAST („**I**nterdisciplinary **C**enter for **A**dvanced **S**cience and **T**echnology”)
Course code	
Type of course	Obligatory subject, Lectures, Seminars, Laboratory exercises
Level of course	Advanced, Doctoral program for biophysics
ECTS	3 ECTS Lectures 10 hours, Seminars 2 hours, Auditorial exercises 4 hours, Laboratory excercises on computer about 2 hours ~ 1 ECTS About 50 hours of preparations for seminars exercises and exam ~ 2 ECTS
Name of lecturer	Professor Vlasta Bonačić-Koutecký
Learning outcomes and competences	Basic knowledge about the state of the art research in the topics listed below including the necessary methodological and technical skills.
Prerequisites	Acceptance in doctoral program for biophysics
Course contents	**I) Metal cluster sensors:** **A) Fundamentals for sensing by small metal clusters:** The aim is to design chromophore-functionalized metal clusters based on the understanding of ground and excited electronic state interactions between metal clusters and photoactive molecules and to exploit them for the efficient enhancement of light absorption and fluorescence. For this purpose we will use the unique optical properties of small noble metal clusters in the nonscalable size regime in which “each atom counts” characterized by strong absorption and emission, combined with biorecognition and functionality of biomolecules. The ultimate goal is in cooperation with experimental groups to design hybrid noble metal cluster-biomolecule based fluorescent sensors. Three routes will be followed: a) Silver cluster-organic hybrid systems at support and in the gas phase b) Ligand-protected silver and gold clusters c) Silver and gold clusters embedded in proteins **B) Probing protein carbonylation by cluster enhanced fluorescence in the context of biological aging** The use of fluorescent markers is a commonly used technique for detecting protein carbonylation. For this purpose organic chromophores such as DNPH have been standardly used. We propose to further enhance the performance of such markers by exploiting cluster enhanced absorption and fluorescence. Such an enhancement effect is required in order to enable in vivo detection of the carbonylation. The advantage of using metal clusters is that they are biocompatible, soluble, robust in terms of optical properties and small enough to go through the cell membranes in contrast to quantum dots. Therefore, small clusters in combination with optical markers such as DNPH are potentially important for sensitive detection and quantification of carbonylation sites. The development of such hybrid markers will be guided by the fundamental studies performed in the part A. This topic will be carried out in cooperation with experimental groups.

	II) Metal clusters as building blocks for new materials **A) Optical and electronic properties of metal cluster-carbon hybrids** Structural and electronic properties of hybrid systems consisting of clusters interacting with carbon structures will be addressed. Our aim is to propose novel hybrid systems with new optical properties such as enhanced absorption and emission in the visible regime by combining the optical response of metal clusters with those of nanodiamonds and graphene. For controlling of the electronic structure of carbon subunits by hybrid formation, the interaction of metal clusters with three-dimensional and two-dimensional carbon nanostructures such as nanodiamonds and graphene will be investigated. The ultimate goal is to propose building blocks for sensing and photonic materials based on metal cluster chromophores stabilized through hybridization with carbon structures, in close cooperation with experimental groups. **B) Optimal control of light propagation and energy transfer in silver cluster nanostructures at graphene** The goal of this topic is to investigate the fundamental aspects of the coherent light propagation and its control in self-organized nanostructures of silver nanoclusters with different size and shape at graphene. Different arrangements of nanoparticles will be studied in which the geometry as well as the distance scale of the system will be varied. The optimal control theory will be applied to manipulate both the light propagation as well as the structural parameters of these nanoparticle clusters with the aim to design specific patterns which will allow the enhancement and localization of the electromagnetic fields. The ultimate goal is to propose building blocks suitable for the development of novel photonic nanoarchitectures. This topic will be carried out in close cooperation with experimentalists.
Recommended reading	Original articles from internationally recognized experts in the field Publications of V. B.-K. et al. and references therein
Supplementary reading	Will be given during the lectures
Teaching methods	Lectures using Powerpoint presentation, material will be available at the homepage
Assessment methods	Written and oral examination
Language of instruction	English
Quality assurance methods	Discussion with participants