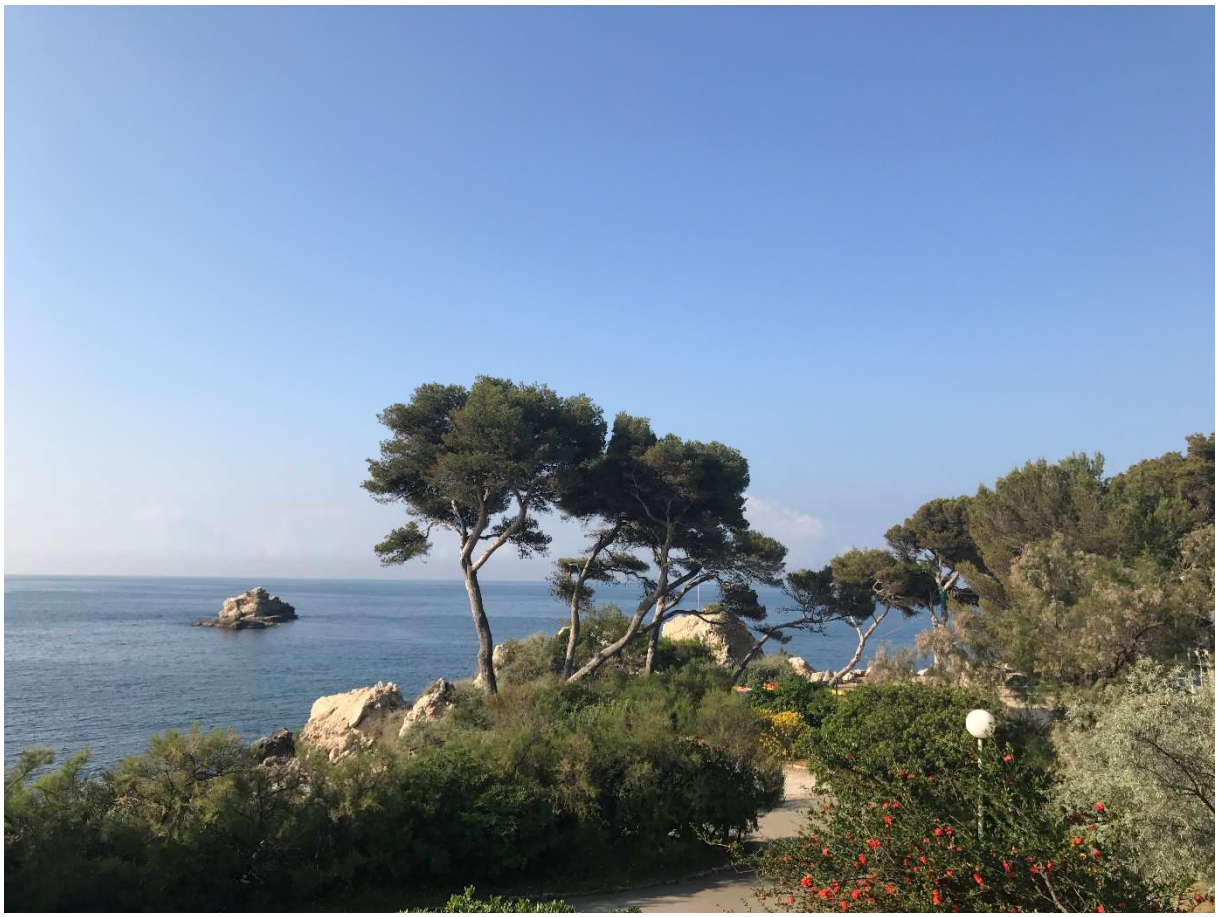
INSTITUT FRESNEL

Journées Des Doctorants de l'Institut Fresnel

7 et 8 juin 2018



Carry-le-Rouet

Jeudi 7 juin 2018

dès 9h00	**Accueil Café devant la salle "Bord de Mer"**		
9h30	**Introduction**		
9h35	**1- AILLOUD Quentin**	CONCEPT	*Systèmes optiques dépolarisants*
9h45	**2- AUDIER Xavier**	MOSAIC	*Fast stimulated Raman scattering with optical delay line*
9H55	**3- GEBRAYEL EL READIY Georges**	ILM	*Laser induced contamination on space optics*
10h05	**4- GIL Marion**	DIMABIO	*Analyse de la diffusion lumineuse de pathologies cornéenne pour la quantification d'efficacité médicamenteuse*
10h15	**5 LASSALLE Emmanuel**	CLARTE	*Photonic Lamb shift of a quantum emitter in the weak-coupling regime*
10h25	**6- MARTIN Benoit**	GSM	*Détection et reconnaissance de cibles d'intérêt dans les images pour la mesure d'audience*
10h40	**Dr Jérôme Wenger** **(MOSAIC)** ***Communiquer sur vos Recherches Scientifiques***		
11h45	**Distribution T-shirt et Photo de groupe**		
12h15	**Pause Déjeuner** ***A partir de 13h15 : Remise échelonnée des clés à la réception***		
14h15	**Dr Caroline Champenois** **PIIM, Marseille** ***Women in Science***		
	De 15h15 à 16h45- Session Posters 1ère Années **16 personnes** (cf. liste) ***Pause-café pendant la session 16h-16h45***		
16h45-17h	**Vote pour les 1A**		
	17h00-19h00 : ACCROBRANCHE ou Temps Libre		
19h00	**Cocktail-Concert, salle bord de mer** **Diner à partir de 20h00**		
21h00 - 00h30	**Soirée (Bar et musique dans la salle)**		

Vendredi 8 juin 2018

	Le Petit-déjeuner est servi de 7h30 à 9h15 – ***Rendu des clés impérativement avant 9h30***		
9h30	**Denis Guthleben** **Attaché scientifique, Comité pour l'histoire du CNRS**		
10h20	**7- MYTSKANIUK Vasyl**	MOSAIC	*Flexible multimodal miniaturized endoscope for non-linear imaging*
10h30	**8- POULIN Cyndie**	ILM CONCEPT	*Etude des matériaux, composants et systèmes pour le domaine Térahertz par analogie aux méthodes optiques*
10h40	Pause Café		
11h00	**9- RIMOLI Caio**	MOSAIC	*Structural Organization of Actin Filaments probed by Polarized Fluorescence Microscopies*
11h10	**10- VEINHARD Matthieu**	ILM	*Laser induced damage of fused silica optical components with centimeter sized beams*
11h20	**invité**		
12h15	Pause Déjeuner		
14h00	**Pr Eric Malbos (IMOTHEP)** ***Psychiatrie et réalité virtuelle***		
14h45	**2ème Années "Ma thèse en 180 secondes"**		
Liste Participants 2A	**1- BOURGADE Antoine**	**RCMO**	*Spatially structured infrared multilayer components*
	2- BOURZGUI Sophia	**DIMABIO**	*Étude du signal optique de détection d'arrêt du temps de polissage du matériau dioxyde de silicium pour les caissons d'isolations de dispositifs microélectroniques*
	3- DE KERNIER Isaure	**MOSAIC**	*Wide-field of view, phase and fluorescence microscopy for applications in hematology*
	4- GAO Guochao	**DIMABIO**	*Analogy between electromagnetic and elastic waves to probe rough interfaces in case of seismic imaging*
	5- GORSHKOVA Oksana	**MOSAIC**	*Nanodynamic Imaging of Leukemic Cell Adhesion*
	6- GUDET Claire	**CLARTE**	*Mimicking metallic and magnetic materials with dielectric materials*
	7- HATIFI Mohamed	**CLARTE**	*Non-linearity and Quantum Mechanics: Limits of the No-Signaling Condition*
	8- HOFER Matthias	**MOSAIC**	*Nonlinear microscopy in scattering media*
	9- MOISSET Charles	**ILM**	*Nano photoinscription 3D de composants photoniques par utilisation des processus d'optique non linéaire*
	10- OLLE Alexandre	**ILM**	*Temporal studies of laser damage for (sub)-picosecond pulses*
	11- PAN Xiaoxi	**GSM**	*Multi-level Feature Representation of FDG-PET Brain Images for Diagnosing Alzheimer's Disease*
	12- SCOTTE Camille	**MOSAIC**	*Compressive Raman microspectroscopy*
	13- UNGER Kevin	**SEMO**	*Electromagnetic imaging techniques in complex media with random illuminations*
	14- VIDAL Thibault	**ILM**	*Interaction Laser-UO2 : Vers la simulation RIA à l'échelle du laboratoire*
	De 16h00 à 17h15 - Session Posters 2ème Années ***Pause-café pendant la session 16h à 16h30***		
	Vote pour les 2A		
17h15	Remise des Prix et Clôture des JDD vers 17h30-17h45		

Liste Participants 1A

Session Poster des 1ère Années		
1- ABAUTRET Yannick	**CONCEPT**	*Recherche de signatures optiques sensibles au stress hydrique de la végétation : étude à l'échelle de la feuille*
2- BARONI Arthur	**COMIX**	*Microscopie de biréfringence par ptychographie vectorielle*
3- BARULIN Alexandr	**MOSAIC**	*UV-Fluorescence correlation spectroscopy*
4- CURCIO Valentina	**MOSAIC**	*Imaging cytoskeletal filament organization at the molecular scale*
5- DURDEVIC Ljiljana	**MOSAIC**	*Photo-magnetic treatment of brain cells*
6- ELTOKHEY Mahmoud	**GSM**	*Multiuser Indoor Visible Light Communications Systems*
7- ESSALIH Taha	**GSM**	*Improving Data-Rate and Reliability of Underwater Wireless Optical Communication Links*
8- HADDAD Oussama	**GSM**	*Channel Modeling and Multiple Access Solutions for VLC-based Intra WBAN Links*
9- IJEH Ikenna	**GSM**	*Adaptive Transmission Schemes for Underwater Wireless Optical Links*
10 - LACARIA Leda	**MOSAIC**	*How αvβ3 and α5β1 integrins influence the mechanical properties of melanoma M21 cells?*
11- MENG Huicheng	**MOSAIC**	*Smart scans: imaging biological tissues faster and with less damage*
12- NATARAJAN Aswani	**ATHENA**	*Modelling of the electromagnetic field in complex nonlinear nanophotonic devices*
13- NIU Dikai	**CONCEPT**	*Design et réalisation d'un nez optique*
14- SILVA MARTINS Carla	**MOSAIC**	*Mechanistic insights into the role of septins in mammalian cell morphogenesis*
15- Le PHAN Trong	**GSM**	*Image Representation Using Graph Theory. Application in Medical Images for Diagnosing Alzheimer's Disease*
16- TRUONG Minh Duy	**ATHENA**	*Theory and numerical modeling of photonic resonances : QUASINORMAL MODAL EXPANSION*

Cette année le Jury c'est vous !

1ère Année : 16 Posters (un Prix)

2ème Année : 14 Présentation « MT180 » suivi des posters (un Prix dans chaque catégorie)

3ème Année : 10 Présentations orales de 10 minutes (un Prix)

Les critères d'évaluations à prendre en compte :

- **Vulgarisation** : expliquer les concepts et les idées dans un langage accessible aux non-scientifiques et non spécialistes du domaine
- **Structure et enchaînement des idées** : logique, clarté des slides, structure du poster
- **Discours** : fluidité, rythme, gestuelle, humour, métaphores, exemples, illustrations…
- **Implication** : transmettre sa passion, susciter la curiosité du public, effort pour parler français
- **Originalité**

Notez les n° de vos 2 interventions favorites sur chaque côté d'un carton

(un carton de couleur différente distribué lors de chaque fin de session)

Déposez-le dans l'urne prévue à cet effet - MERCI !

RESUMES DES 1ère ANNEES

Recherche de signatures optiques sensibles au stress hydrique de la végétation : étude à l'échelle de la feuille

ABAUTRET Yannick – CONCEPT
Directeurs de thèse : Myriam Zerrad et Claude Amra

L'agriculture des prochaines décennies devra faire face au changement climatique global et aux enjeux alimentaires mondiaux. Les ressources en eaux se raréfient alors que les besoins de nourritures augmentent avec l'accroissement de la population. Si la modification de nos modes de surconsommations semble-être un élément indispensable à l'émancipation d'une solution saine et pérenne, elle ne sera certainement pas suffisante pour y parvenir. Les plantes alimentaires, gourmandes en eau et en nutriments, devront soit s'adapter à nos besoins, soit être génétiquement sélectionnées par l'homme pour être capable de produire encore plus et avec moins.

La sélection génétique n'est pas chose aisée puisque dans le cadre de notre étude, il est question d'observer et/ou de mesurer des quantités « optiques » à l'échelle de la feuille de tournesol, susceptibles de donner une information relative à la capacité des espèces à résister au stress hydrique.

Jusqu'ici, les mesures optiques sur les végétaux à des fins de pilotages agroalimentaires concernaient essentiellement des échelles plus larges comme des images satellites ou de drones au-dessus d'un champ par exemple. L'étude à l'échelle de la feuille, plus rarement considérée, est au cœur de ce travail de thèse. Elle est un premier pas vers une meilleure compréhension des signaux optiques propres aux végétaux en vue de leur utilisation pour une agriculture de précision.

Microscopie de biréfringence par ptychographie vectorielle

BARONI Arthur – COMIX
Directeurs de thèse : Patrick Ferrand et Virginie Chamard

La ptychographie est une approche récente d'imagerie basée sur l'acquisition de multiples clichés de diffraction et la reconstruction numérique de l'objet étudié par un algorithme itératif. En microscopie optique, cette méthode offre comme avantages majeurs l'acquisition d'un champ de vue aussi grand que souhaité et d'obtenir une carte de phase de l'objet étudié. Initialement développée pour la microscopie électronique et les rayons X, la ptychographie repose sur un formalisme scalaire, ne prenant donc en compte ni les propriétés de polarisation de la lumière, ni la possibilité de matériaux biréfringents. Cette limitation exclut donc une grande variété de matériaux qu'ils soient minéraux ou organiques (milieu cellulaire, plastiques sous contraintes, etc.). Nous avons développé une variante vectorielle à la ptychographie, qui généralise la modélisation de l'interaction lumière-matière, ce qui nous permet de reconstruire la matrice de Jones en chaque point de l'objet et donc de cartographier ses propriétés optiques. Je travaille sur

le développement de cette nouvelle ptychographie et ses algorithmes de reconstruction, les spécificités du formalisme vectoriel, ainsi que son implémentation expérimentale. J'expérimente cette technique sur des spécimens biominéraux dans le but de comprendre les mécanismes de biominéralisations.

UV-Fluorescence correlation spectroscopy

BARULIN Aleksandr – MOSAIC
Directeur de thèse : Jérôme Wenger

Fluorescence correlation spectroscopy (FCS) relies on computing autocorrelation of intensity fluctuating with time because of single fluorescent molecules passing through a focal volume of the confocal microscope. This analysis together with the time-correlated single photon counting (TCSPC) technique can give information about molecular dynamics, lifetime of the excited state, biochemical interactions, as well as photochemical and photophysical properties of single molecules. However, to implement these analyses, one must attach fluorescent dyes to macromolecules, whereas fluorescent labels can interfere the molecular dynamics and biochemical properties because of their large size. Eliminating the fluorescent labels and investigating autofluorescence of proteins is possible while deep UV (200-300 nm) excitation light is used. There are three natural aminoacids: tryptophan (Trp), tyrosine (Tyr) and phenylalanine (Phe) which are fluorescent in the deep UV, and since they are present in many proteins they serve as a natural fluorophore. However, working in the deep UV implies increased chromatic aberration of the objective, low fluorescence signal and high intensity background of contaminants in the solvent.

In our work we built a UV excitation confocal microscope and investigated different optical setup configurations for correcting chromatic aberration and increasing collection efficiency. P-terphenyl was used as high quantum yield UV fluorescent molecules for running FCS and TCSPC. It was dissolved in such solvents as cyclohexane, ethanol, n-hexane, dimethylformamide (DMF) and dimethyl sulfoxide (DMSO), which showed different fluorescence background levels.

Imaging cytoskeletal filament organization at the molecular scale

CURCIO Valentina – MOSAIC
Directeurs de thèse : Sophie Brasselet et Pascal Verdier-Pinard
(Centre de Recherche en Cancérologie de Marseille)

My thesis work aims at implementing a new polarized fluorescence microscopy for cell biology. While determining the localization of single fluorescent molecules with nanometer precision, this technique enables the measurement of their 3D orientation and degree of organization at the same time. Retrieving localization and 2D orientation of molecules in the focal plane with the polar-dSTORM technique was achieved (Valades Cruz et al., *PNAS*, 2016), but measuring the out-of-plane component of polarization is still a technical challenge. Indeed, a fluorescent dipole polarized in a direction parallel to the optical axis will absorb and emit light propagating mostly orthogonally to the optical axis, and will be thus poorly collected by the

objective. I am addressing this problem by using TIRF (Total Internal Reflection Fluorescence) illumination to excite the out-of-plane component. The emitted light is then collected by a high-NA objective, and an appropriate filtering is done in its back focal plane, where the intensity distribution of light is strongly dependent on the out-of-plane orientation, enabling us to retrieve it.

This improved polarized fluorescence microscopy technique will be a powerful tool to address biological questions, since this novel organizational information is particularly important to assess the role of cytoskeletal filaments. In particular, I am interested in applying this approach to septins, a family of cytoskeletal proteins whose 3D temporal organization during the cytokinesis phase of dividing cells is still poorly defined.

Photo-magnetic treatment of brain cells

DURDEVIC Ljiljana – MOSAIC / Regenlife Company

Directeurs de thèse : Guillaume Baffou, Guillaume Blivet, Serge Monneret

Neurodegeneration includes a wide range of disorders, with the most common being Alzheimer's disease. Recently, it has been shown that applying light on neuro-degenerated brains can efficiently reduce symptoms. This kind of light treatment is called photo-therapy.

The newest discovery reported by Regenlife Company has shown that light combined with static magnetic field can lead to even more impressive healing results. They have managed to completely cure mice from Alzheimer's disease. However, underlying mechanisms of this photo-magnetic treatment have been poorly understood, or better to say, mysterious.

In this PhD, such a photo-magnetic treatment will be applied at the level of single neuron cells in culture. The purpose of conducting such experiments is two-fold: clarifying the underlying mechanisms of this newly reported photo-magnetic therapy and optimizing the physical parameters. This PhD is in CIFRE convention between Regenlife and Institut Fresnel.

Multiuser Indoor Visible Light Communications Systems

ELTOKHEY Mahmoud – GSM

Directeurs de thèse : Ali Khalighi, Nicolas Bertaux et Zabih Ghassemlooy,

Optical wireless communications (OWC) has recently emerged as a solution to augment radio-frequency-based transmission systems, especially for indoor environments where up to 70% of wireless traffic takes place. An interesting approach is to exploit the visible part of the spectrum; what is referred to as visible light communications (VLC). Advantages such as unregulated spectrum, low cost, and implementation simplicity, are encouraging the use of the VLC technology in a variety of applications. However, such links potentially suffer from problems including the degradation in signal-to-noise ratio due to the presence of ambient noise sources, and multiple reflections that can (in special circumstances) impact the achievable data rate.

In this PhD thesis, we aim at developing efficient multiple access techniques for indoor VLC systems in order to allow simultaneous transmissions between multiple users and an access point. Towards achieving this goal, we specially take into account practical considerations such as implementation complexity, and quality of service. Afterwards, we work on developing

appropriate cellular architectures for such VLC systems in relatively large space scenarios in order to account for user mobility. Experimental validation of the proposed solutions will be carried out as well.

Improving Data-Rate and Reliability of Underwater Wireless Optical Communication Links

ESSALIH Taha - GSM - ILM

Directeurs de thèse : Ali Khalighi et Hassan Akhouayri

As water represents about 71% of the earth surface, underwater life and resources have always raised the interest of the humankind to explore them. The equipment required for this purpose of discovering the underwater world comes into the necessity of underwater communication in order to collect and analyse the related data. Among the possible underwater wireless communication technologies, the use of optical waves appears to be a promising approach in some particular application areas.

Focusing hence on underwater wireless optical communications (UWOC), this thesis aims at enhancing the data rate, link range, and the robustness of such communication links. We particularly consider the use of ultra-sensitive photo-detectors, i.e. Silicon photo-multipliers (SiPMs) that have the potential of increasing considerably the link span. We will work on the development of advanced modulation schemes and error correcting codes to deal with the bandwidth limitation and non-linear characteristics of these components while taking into account the particularities of typical application scenarios and water characteristics. We will also design appropriate MIMO (Multiple Input Multiple Output) architectures in order to improve further the link robustness and performance.

Channel Modeling and Multiple Access Solutions for VLC-based Intra WBAN Links

HADDAD Oussama – GSM

Directeurs de thèse : Ali Khalighi, Mouloud Adel et Volker Jungnickel (Fraunhofer HHI)

Wireless body area networks (WBANs), connecting a number of sensors placed around and inside the human body, are a promising technology in medical applications by improving healthcare services through, for example, patient monitoring and remote control of medical devices. Radiofrequency-based WBANs suffer from several drawbacks including the risk of electromagnetic interference, the specific absorption rate limitations near the body surface, as well as data security (i.e. vulnerability too eavesdropping), and multipath propagation.

To overcome these limitations, visible light communications (VLC) have emerged as a viable alternative for wireless data exchange between WBAN nodes.

In this thesis, realistic indoor VLC channel modeling and characterization of in- and on-body WBAN links will be performed. The effects of body configuration, its position inside the room, and the placement of sensors will be taken into account as well. Also, we will work on the development of optimal multiple access (MA) techniques and efficient physical and upper-layer signaling schemes for interconnecting medical sensors, while satisfying the requirements

of user mobility, low energy consumption, and low implementation complexity. Furthermore, we will propose efficient solutions for time synchronization and MA interference management.

Experimental verification of the developed VLC-based network will be done at the last stages of the thesis.

Adaptive Transmission Schemes for Underwater Wireless Optical Links

IJEH Ikenna – GSM

Directeur de thèse : Ali Khalighi, Co-encadrant: Julien Marot

The increase of activities underwater has paddled the need for an improved and reliable communication technology, which takes into account the peculiarities of the aquatic media. Most of the present underwater communication systems, e.g. acoustic-based, are inadequate in meeting these demands due to the limitations related to their fundamental operating principles, including the available bandwidth, level of celerity and latency.

Underwater wireless optical communication (UWOC) systems are able to provide high-data-rate transmission and are also highly energy efficient, hence seems to be a robust alternative for the inadequacies of acoustic communication systems for some specific applications.

This thesis considers the transmission link of an operational UWOC system with the intent to optimize the link performance using adaptation strategies. Parameters and functions affecting link range, data-rate, and transmitter-receiver alignment will be considered with respect to the operating conditions. Adaptive transmission strategies will be investigated both in the physical and the data link layers, with the possible design of cross-layer adaptive schemes. It is feasible that different optimization schemes would be concluded; hence, there would be a need to propose a trade-off with respect to practical considerations of link deployment.

How αvβ3 and α5β1 integrins influence the mechanical properties of melanoma M21 cells?

LEDA Lacaria – MOSAIC and LAI Lab FM group

Directeurs de thèse : Félix Rico et Loïc Le Goff

Living cells are able to produce and sense forces from the external environment through the cytoskeleton. The connection between the external environment and the cytoskeleton is the integrin. Indeed, integrins are surface adhesion receptors and play a fundamental role in transducing mechanical signals into chemical ones and vice versa, between the extracellular matrix and the cytoskeleton, the outside and the inside of the cell. Therefore integrins support mechanical forces, allowing cells to generate internal tension. One the one hand, several studies show that cancer progression alters mechanical properties of the cell, but it is still unclear which are the causes of this alteration; on the other hand, overexpression of αvβ3 integrin has been observed in endothelial cancer as well as melanoma cells. Starting from these observations. Our aim is to determine the role of α5β1 and αVβ3 integrins in maintaining the elasticity of adherent

melanoma M21 cells using the Atomic Force Microscopy in Force Mapping mode. This technique allows to measure the elasticity across the cell surface. To distinguish the specific effect of each integrin, we compared the elasticity of two cell types derived from the same cell line: M21 (expressing α5β1 and αVβ3 integrins) and M21L (expressing only α5β1 integrin). We determined the Young's modulus of the two cell types cultured on bare substrates. Our preliminary results suggest that the Young's modulus in M21 cells is higher than in M21L cells.

Smart scans: imaging biological tissues faster and with less damage

Huicheng MENG – MOSAIC
Directeur de thèse : Loic Le Goff

The Laser Confocal Scanning Microscopy (LCSM) is an instrument which provides optical sectioning when imaging biological structures in depth. The confocal microscope and its different variations have fostered a revolution in life sciences: one can now image entire tissues at a sub-cellular resolution in a living organism. However, confocal microscopes (linear or non-linear) are slow and quite phototoxic, because they scan the excitation laser in the entire field of view in a raster fashion, which takes time and significant amount of light. At present, the informed scan introduces a new paradigm in microscopy, where the imaging process adapts in real time to the information content of the sample.

We aim at developing a novel confocal microscope that improves the performance of laser scanning microscopes by making them decreasing photo toxicity, and enhancing scanning speed for in vivo imaging. In order to do so, the system will use prior information of the imaged sample to focus exclusively on the structures of interest and thus avoid wasting light and time on regions that bear no information. The prior information will first come from the user informing on the structure of the imaged tissue. For example, the tissue may be a curved cell monolayer in which we want to image the apical shape of cells. The prior will also come from the redundancy from one time point to the next.

Modelling of the electromagnetic field in complex nonlinear nanophotonic devices

NATARAJAN Aswani – ATHENA
Directeurs de thèse : Gilles Renversez et Guillaume Demésy

Thanks to the improvements in the fabrication processes in nanophotonic, it is now possible to combine nonlinear materials, complex 3D structures and the use of 2D materials like graphene.

Nevertheless, it appears that such complicated optical devices are not modelled in a satisfactory way and that their nonlinear characteristics are not always correctly evaluated inducing poor or misleading assessments of the device figure of merit in terms of data processing. In the present PhD work, we plan to model rigorously nonlinear anisotropic waveguides with a 2D cross-section along their propagation axis when some of their parts are

made of a single layer of graphene (or other 2D materials that are now available) in order to evaluate in valid way their properties.

To realize these tasks, the finite element method in the framework of the Galerkin approach will be used both in eigen-value problems and in scattering problems, based on the different methods and tools developed in the Athena research team. In the final part of the PhD work, Finite-difference time-domain simulations will also be performed to investigate the temporal aspects of light propagation in such complex non-linear nanophotonic devices. A new spatial model recently developed by Gilles Renversez that can reduce the full vector nonlinear propagation problem will also be employed and tested. It is worth mentioning that in the framework of a collaboration initiated by the Athena team, a consortium of French experimental research teams has already been able to combine highly nonlinear materials and graphene. New samples will be fabricated to allow full optical characterizations both in the linear and nonlinear regimes. These results should make possible promising comparisons between experimental results and the correct modelling we are developing.

Design et réalisation d'un nez optique

NIU Dikai – CONCEPT
Directrice de thèse : Myriam Zerrad

La qualité de l'air est un enjeu majeur mondial du point de vue de l'air ambiant extérieur, notamment pour la maitrise des gaz à effet de serre (CO2, CH4..) mais également pour la santé des populations avec la maitrise et la diminution des substances toxiques (NOx, PM, Composés CMR Cancérogène Mutagène Toxiques pour la reproduction, etc...).

La qualité de l'air intérieur véhicule est soumise depuis 2013 aux premières règlementations sur les VOC émis dans l'habitacle (Corée, travaux sur une recommandation internationale GRPE). La Chine est particulièrement impliquée dans la réduction des agents chimiques dangereux dans l'habitacle (règlementation VIAQ – Vehicle Interior Air Quality) en cours de finalisation.

Le défi technique est de mesurer avec fiabilité et précision l'odeur dans l'habitacle véhicule et de permettre le contrôle en validation, en clientèles. L'enjeu consumériste étant bien sûr de se positionner parmi les meilleurs au niveau des retours enquêtes clients sur l'item « odeur intérieur véhicule ».

On va développer une méthode de synthèse originale pour guider la fabrication d'empilements multi diélectriques supportant des exaltations géantes du champ optique en espace libre. De telles exaltations présentent un intérêt majeur, notamment dans le domaine des capteurs optiques ultra-sensibles et celui des sources lumineuses intégrées.

Mechanistic insights into the role of septins in mammalian cell morphogenesis

SILVA-MARTINS Carla – MOSAIC
Directeurs de thèse: Manos Mavrakis et Stéphanie Cabantous

The regulation of cell adhesion and motility is crucial for animal physiology, especially for tissue morphogenesis and organogenesis. Animal cells utilize higher-order actin filament assemblies known as stress fibres (SFs) to promote this migratory behavior. Septins are cytoskeletal proteins that bind SFs and which are essential for SF formation, but their function is still poorly understood. A key feature of septins is that they form heteromeric complexes which lead to septin filaments. Although the filamentous form of septins is thought to be their functional form, direct evidence that human septins organize and function as filaments in cells is missing.

This PhD thesis has the goal to explore important aspects of human septin organization and function in the context of cell adhesion and motility using stress fibres as a model system. First, we are mapping the distribution of septin in order to assess if distinct septin populations associate with specific SF subtypes. Next, we will employ a tripartite split-GFP complementation assay to investigate if human septin assemble into filaments in adherent cells. Then, we will study how septin filament is organized, using polarization-resolved fluorescent microscopy, and how it interplays with F-actin architecture. Finally, we will explore where septins are in the signaling pathway regulating SF assembly.

Image Representation Using Graph Theory
Application in Medical Images for Diagnosing Alzheimer's Disease

PHAN Trong-Le – GSM
Directeur de thèse : Mouloud Adel

As it is reported in 2015 World Alzheimer Report, every 3 seconds someone in the world develops Alzheimer's Disease (AD) or other dementia (9.9 million new cases), and the number of people worldwide living with dementia will almost double every 20 years (46.8 million in 2015). In the US, 1 in 3 seniors dies with AD or another dementia. Early diagnosis or precise prediction of neurodegenerative stages can help patients avoid unnecessary and costly treatments. Together with blood test, intellectual functioning assessment, etc., observations on medical images (e.g. MRI, PET) have a crucial role in diagnosing AD. The uptake of biomarkers, e.g. glucose, in diseased brain cells is visually different from healthy ones. With this indicator, we try to segment the images into regions of interest (ROI) for a better observation on brain parts showing the abnormal metabolism of biomarkers.

One way to segment medical images is to use the human brain atlas Automated Anatomical Labeling (AAL), which has been widely used by neurologists and radiologists and in other research. However, what we predict is that brain segments corresponding to AD may more or less vary among people, and in fact, not every section in the brain is relevant to AD. With this in mind, instead of using a fixed number of ROI from AAL (normally 116), we expect to find an optimal number and shape of ROI according with each single patient in order to

achieve higher accuracy in classification between AD stage groups (Healthy Control vs. AD, progressive vs. stable Mild Cognitive Impairment). Moreover, the use of graph theory defined as a network of nodes and edges would be helpful and effective in brain representation and segment clustering. With an assistance from a doctor in collaboration with this work, we evaluate the results both visually and statistically.

Theory and numerical modeling of photonic resonances: QUASINORMAL MODAL EXPANSION

TRUONG Minh Duy – ATHENA

Directeurs de thèse : André Nicolet et Philippe Lalanne (LP2N-Bordeaux)

Nano-optics studies the interaction between electromagnetic field (light) and matter at the nanometer scale (dimensions much smaller than the wavelength of electromagnetic radiation). The computational analysis and design in nano-optics heavily rely on the concept of optical resonance, privileged vibrational states of the optical system. From a mathematical point of view, such resonance of open optical system corresponds to eigen-solutions of source-free Maxwell's equations, called Quasi Normal Modes (QNMs). As a result, the study of modal analysis of these QNMs is highly demanded in order to understand physical insights of optical response of open nano-optics resonators. Unfortunately, the rigorous mathematical modal theory for QNMs remains incomplete considering that quasi-normal eigenmodes are not orthogonal in a common sense.

In this work, I present my study of QNM expansion method, the technique of decomposition of electromagnetic field into a basis set of QNMs. This method uses the biorthogonal property of adjoint eigenmodes to overcome the fact that QNM eigenmodes are not orthogonal to each other. First, in order to obtain QNMs, one has to solve non-linear spectral problems, source-free Maxwell's equations in dispersive materials with frequency-dependent permittivity. QNM expansion is implemented on a 2-D metallic diffraction grating where the problem is both open and periodic. The computational domain is then bounded by using Perfectly Matched Layers (PML) to truncate the free space along one direction and Floquet-Bloch theory as quasi-periodicity conditions along the others. Next, the continuous problem is discretized by Finite Element Analysis on Onelab/Gmsh/GetDP open source packages. Numerical eigenvalues are computed through eigenvalue solver library SLEPc.

Acknowlegement: This work is supported by the ANR RESONANCE project, grant ANR-16-CE24-0013 of the French Agence Nationale de la Recherche.

Doctorants de 1ère année Absents aux JDD

Imagerie par Résonance Magnétique Ultra Haut Champ

MOUSSU Marine – CLARTE

Directeurs de thèse : Stefan Enoch, Redha Abdeddaim
et Elodie Georget-Paris (MULTIWAVE INNOVATION)

L'IRM est une modalité d'imagerie médicale non invasive qui permet l'acquisition d'images du corps humain en 3D. Elle est fondée sur la propriété de certains noyaux à présenter une aimantation microscopique appelée spin. Le noyau d'hydrogène est en général utilisé car il est présent en très grande quantité dans les tissus biologiques. Ces noyaux, au préalable plongés dans un champ magnétique statique d'intensité B_0, sont perturbés à l'aide d'une impulsion centrée sur la fréquence de Larmor, qui dépend à la fois de B_0 et de la nature des noyaux. En revenant à leur état initial, les spins émettent un signal, conditionné par leur environnement, qui est ensuite utilisé pour reconstruire une carte de la densité spatiale de noyaux. La qualité de l'image dépend grandement du rapport signal à bruit, lui-même influencé par la grandeur B_0 à laquelle est proportionnelle l'intensité du signal, et par la chaîne d'émission-réception dont les performances participent directement au niveau de bruit. Aujourd'hui, la tendance en recherche est à l'augmentation de B_0, qui conduit de fait à une diminution de la longueur d'onde des champs électromagnétiques mis en jeu à l'émission et à la réception. Dès lors que cette longueur d'onde devient comparable à la taille de l'organe à imager - on parle alors d'IRM à ultra haut champ - des phénomènes d'interférences au sein de l'échantillon induisent une distribution de champ d'excitation inhomogène au sein de l'échantillon, résultant en une image inégalement reconstruite. Actuellement, le défi majeur auquel est confrontée la recherche en IRM est de développer de nouvelles stratégies d'émission-réception pour compenser ces inhomogénéités.

RESUMES DES 2ème ANNEES
MT180' + Posters

Spatially structured infrared multilayer components

BOURGADE Antoine – RCMO
Directeur de thèse : Julien Lumeau

For the past couple of decades, there has been huge progress within the fabrication method and the complexity of optical thin film filters. Coatings can now be accurate at nanometric scales even for stacks up to hundreds of layers. However, more and more uniform and performant filters are now needed, requiring better and better control of the processes during the deposition. Spectral performances of a filter are related to the optical thickness of each layer and performances are fixed at filter achievement. To overcome this limitation, the use of materials which index of refractive index or thickness (and therefore the transmitted or reflected phase) can be locally changed after deposition appears as an attractive solution.

The PhD project concerns the development and manufacturing of optical thin films based on photosensitive materials and the integration of these layers into complex multilayer stacks. As a material, we based our research on chalcogenide glasses such as As2S3 also known as AMTIR-6. These glasses are known for their broad transparency in the near and far infrared (AMTIR stands for Amorphous Material Transmitting Infrared Radiations) and have the unique characteristic of being photosensitive, i.e. some of its opto-geometrical properties can be modified after exposure to actinic radiation. Very large refractive index change up to 0.1 and large thickness change as large as 8.3 % of the total thickness have been demonstrated in e-beam evaporated As2S3 layers.

Using these photosensitive properties of the chalcogenide glass-based layers, volume micro and nano-structures in thin films and multilayer stacks can be created and will allow the development of new features and infrared components.

We show that the photosensitive properties can be used to produce very uniform Fabry-Perot filters over surfaces of several hundreds of mm². Indeed, by inserting a thin film As2S3 layer within the cavity of a bandpass filter, it becomes possible to compensate for the local change of thickness of each of the layers associated with the non-uniformity of the deposition by an equal relative change of the refractive index with opposite sign, resulting in a constant optical thickness over the filter aperture.

Another application concerns the production of volumetric phase plates for beam shaping using a thin film layer of As2S3 surrounded by 2 anti-reflection coatings. Those volumetric phase plates are then created not by a local change of thickness as it is generally the case but by a local change of the refractive index with pre-defined spatial profiles.

Étude du signal optique de détection d'arrêt du temps de polissage du matériau dioxyde de silicium pour les caissons d'isolations de dispositifs microélectroniques.

BOURZGUI Sophia – DIMABIO
Directrice de thèse : Gaëlle Georges

Le polissage mécano-chimique (CMP) intervenant au niveau des zones actives représente une étape critique dans le processus de fabrication des puces électroniques. Cette étape consiste à polir l'oxyde de silicium jusqu'aux zones actives en respectant un cahier des charges stricte. En outre, il est essentiel d'avoir une bonne maîtrise de la planarisation, i.e. un polissage uniforme sur l'ensemble du wafer, un « dishing » faible, autrement dit, ne pas creuser l'oxyde au centre de la tranchée d'isolation et finalement, un respect des spécifications en termes d'épaisseur des matériaux polis. Dans ce contexte, il est important d'améliorer le procédé de fabrication, notamment en mettant en place des outils de contrôle du temps de processus de fabrication en fonction des paramètres d'entrée (épaisseur du matériau à polir, densité des motifs sur le wafer). Le sujet de recherche présenté est l'étude du signal optique de détection d'arrêt du temps de polissage du matériau dioxyde de silicium. Comparativement à un processus de polissage avec un temps unique pour l'ensemble des wafers du même produit, contrôler le temps de polissage wafer par wafer permet d'améliorer la dispersion de l'épaisseur après polissage. L'objectif de cette recherche est donc de mettre en évidence les paramètres de recette de polissage et les paramètres du produit qui influent sur la forme du signal optique en termes d'amplitude, de bruit et de période et de proposer un algorithme de détection adapté à chaque produit.

Wide-field of view, phase and fluorescence microscopy for applications in hematology

De KERNIER Isaure – MOSAIC
Directeur de thèse : Serge Monneret

Microscopy systems strive to provide superior image quality through higher resolution and signal-to-noise ratio, resulting in systems with high imaging performances but bulky, ultra-specific and expensive. Furthermore because resolution is the gain-stake, these systems sacrifice the field-of-view. Recently, some research teams have started to develop affordable imaging systems for Point-Of-Care (POC) applications. In the particular case of holographic lensless imaging, micrometric resolution and a wide field-of-view are combined. Unfortunately, these imaging system all tend to be mono-modal.

Phase and fluorescence are complementary contrasts to observe a biological object. Fluorescence is an intrinsically selective technique, by using the appropriate probe, specific structures or functions of the cell can be labelled and imaged with a high signal-to-noise ratio. Phase contrast on the other hand shows changes in optical-path-length (OPL) enabling contrasted imaging of non-absorbent cells that are not visible in transmission microscopy

We propose two set-ups and the associated phase reconstruction algorithms to perform bimodal imaging on large fields-of-views. This full-field coupling allows access to statistical information. In particular, we are interested in studying infected blood cell population.

Analogy between electromagnetic and elastic waves to probe rough interfaces in case of seismic imaging

GAO Guochao – DIMABIO
Directeurs de thèse : Carole Deumié, Paul Cristini et Nathalie Favretto-Cristini

In the exploration seismology, multicomponent data, recoded by three orthogonal vector sensors (composed by vertical, inline horizontal and crossline horizontal geophones) on the surface of earth, is usually the raw data. The elastic seismic wave propagating in the subsurface medium consists of three different wave modes: one compressional mode P and two shear modes, SV and SH. A key distinction among those wave modes, in term of the particle-displacement vector (i.e. polarization states), is that each mode **distorts** the earth in a different direction along its propagation path.

Different wave modes react to changes in the earth's elastic constants in different ways, multicomponent data, which carries different geologic information for the same illuminated area, thus can detect and reveal different subsurface rock and fluid properties (such as petrophysical, stratigraphic-sequence, and facies information), and then can be used to create subsurface image.

In 2D case, only P compressional mode and SV shear mode appear, but both wave modes are linked to each other, and energy is exchanged between those two modes during reflection on the subsurface interface.

Polarization analysis, which quantitatively describes the particle motion of a seismic wavefield, is the fundamental vector processing technique applied to multicomponent seismic data. Polarization analysis can facilitate the extraction of pure P and S-wave sections, removal of unwanted noise events, and recovery of information relating to fracturing, porosity and lithology from multicomponent data. Therefore, we want to investigate how rough interfaces change the polarization states and how we characterize the polarization states of the seismic waves reflected on the rough interfaces, and further use these polarization characterizations to effectively image them.

Nanodynamic Imaging of Leukemic Cell Adhesion

GORSHKOVA Oksana – MOSAIC / CRCM
Directeurs de thèse: Serge Monneret, Michel Aurrand-Lions
et Arnauld Serge (CRCM)

The study of adhesion process of leukemic stem cells to stromal cells and to collagen fibers will improve leukemia treatment. Interactions between Junctional Adhesion Molecules C (JAM-C) expressing leukemic stem cells and JAM-B-expressing stromal cells are deeply revised in leukemia context, provoking resistance to chemotherapy, relapses and tumor evolution. It was shown (Kuter, 2007) that collagen arrangement in bone marrow reveals the cancer stage.

In this project, we propose to combine single molecule fluorescence (SMF) imaging (Sergé, 2008) in the visible wavelength range for JAM tracking, with both phase and intensity collagen imaging (Aknoun, 2014) in the infrared spectral range. This ultra-resolved imaging will document the role of JAMs in the dynamic establishment of cell/cell and cell/extracellular matrix adhesion in real time. We intend to improve our imaging techniques with high-speed

low-noise EMCCD cameras (able to run up to 3500 frames/s with sub-electron readout noise), provided by our partners (First Light Imaging) in frames of the project. We found out that the antibodies we use for SMF imaging effect on JAM-B and JAM-C interactions. These antibodies may be used for leukemia therapy. The combined imaging system will be used for cancer stage diagnosis as well as for drug tests.

Mimicking metallic and magnetic materials with dielectric materials

GUIDET Claire – CLARTE
Directeurs de thèse : Nicolas Bonod et Redha Abdeddaim

Metallic particles can resonate with electromagnetic waves because of the excitation of surface plasmons. Dielectric particles can have a resonant interaction with electromagnetic waves due to the excitation of Mie resonances. It has been shown that the resonant electromagnetic response of a metallic particle can be reproduced by a dielectric particle.

One of the goal of the thesis is to optimize the dipolar magnetic Mie coefficient, $bb1$. For a given permittivity, we would like to predict the frequency which would maximize $bb1$. We use different analytic expansions of the Mie coefficients to make the predictions. Then, we use CST (a simulation software) to check the validity and accuracy of these models and to study the impact of losses. Finally, we found that a particle with a permittivity of 55 could behave as a particle with a permeability of -2.45.

Our next step is the experiment. We would like to test if the calculation and simulation give us the expected result. Also we are considering to build those resonators.

Non-linearity and Quantum Mechanics: Limits of the No-Signaling Condition

HATIFI Mohamed – CLARTE
Directeur de thèse : Thomas Durt

The linearity of the Schroedinger equation has the status of a postulate: it is usually postulated to be valid, always and everywhere. Linearity is also congenitally linked to the vectorial space nature of the quantum state space (Hilbert space) as well as to the superposition principle. The superposition principle is in turn at the origin of serious and fundamental problems (e.g. the Schroedinger cat paradox and the so-called measurement problem), and there were in the past several attempts to investigate non-linear generalisations of Schroedinger equation. We are interested in studying deterministic non-linear modifications of the Schroedinger equation `a la Diosi-Penrose. This theory predicts that whenever coherent superpositions of macroscopically distinct localisations occur in nature, they will compete due to the non-local nature of the self-gravitational energy. We expect that, similar to optical rogue waves, the non-linearity will act as a noise amplifier, which, combined with non-local energy transfer, results in the stochastic appearance of spontaneous localizations (quantum jumps). Our aim is to model this scenario, focusing on possible violations of the no-signaling condition, which was shown by Gisin to be a corollary of non-linearity. We also plan to study the interplay between non-linear wave mechanics and de Broglie guidance relation. Besides its interest

concerning the foundations of the quantum theory, this work also presents applications in various fields of physics such as non-linear optics (optical rogue waves and solitons) and hydrodynamics (bouncing oil droplets).

Nonlinear microscopy in scattering media

HOFER Matthias – MOSAIC
Directrice de thèse : Sophie Brasselet

Imaging deep in biological structures is fundamentally limited by light scattering. Consider a light emitting point-source in an inhomogeneous medium – let it be fluorescence, or any other nonlinear generated signal – it will turn into a speckle after propagating through the medium. This is true for the excitation and the detection light. The beauty in nonlinear microscopy lies in the fact that the nonlinear photons are only generated under tightly focused beams in space and time, thus allowing it to be a 3D sectioning technique. In the same time, the need for a focus for nonlinear photon generation is the curse for imaging structures deep in biological tissue. Wavefront shaping has proven to provide the capability of refocusing a scattered pulse and even to manipulate the spectral phase of a pulse such that it is recompressed after the propagation through a scattering medium. Through phase-stepping interferometry it is feasible to measure the transmission matrix (TM) of a scattering medium which relates the input field to the output field. Similarly, reflection of linear or nonlinear photons can reveal propagation properties in scattering media. Still, some of the nonlinear contrasts require interaction of two distinct wavelengths (i.e. CARS, SRS, SFG). Therefore, it is inevitable to control both beams which are spectrally separated such that they manifest itself as two uncorrelated speckles behind the scattering medium. In this project, we want to exploit the capacity of wavefront shaping for refocusing and therefore generating a nonlinear signal behind and in scattering media.

Nano photoinscription 3D de composants photoniques par utilisation des processus d'optique non linéaire.

MOISSET Charles – ILM
Directeurs de thèse : Jean-Yves Natoli et Konstantinos Iliopoulos

La résolution en inscription laser est gouvernée par la limite de diffraction. Cette limite correspond à la plus petite tache laser accessible avec une longueur d'onde et un système de focalisation donnés. Pour améliorer cette résolution, l'absorption à deux ou plusieurs photons peut être utilisée. Cette méthode permet également l'inscription en 3 dimensions.

Dans l'idée d'encore diminuer la zone d'interaction, deux phénomènes d'optique non-linéaire (ONL) privilégiés peuvent être envisagés. L'absorption saturable et l'auto-focalisation. Pour utiliser ces phénomènes, une structure en multicouche est proposée. D'abord un masque composé d'une couche mince d'un chalcogénure. Le Sb2Te3 est un matériau de choix, connu pour ses importantes propriétés ONL. L'inscription sera effectuée dans une deuxième couche située sous le masque.

Afin d'étudier la réponse ONL de la première couche la technique du Z-scan a été utilisée. L'étude des propriétés ONL du Sb2Te3 (couches minces de 24 nm) montre une très importante absorption saturable, le paramètre d'absorption non linéaire β a été mesuré à -10-3 m/W en régime nanoseconde et -10-6 m/W en régime femtoseconde. Il a aussi été montré que cette réponse est fortement corrélée avec l'état de cristallisation de l'échantillon. En effet sous sa forme amorphe la réponse est alors presque négligeable.

Des simulations ont montré que la super-résolution peut être atteinte avec ce matériau et une étude expérimentale à venir confirmera ses résultats de simulation.

Temporal studies of laser damage for (sub)-picosecond pulses

OLLÉ Alexandre – ILM / CEA

Directeurs de thèse : Laurent Gallais et Laurent Lamaignère (CEA CESTA)

Located in CEA-CESTA and sharing the same facility as the LMJ (Laser Méga Joule), PETAL (PETawatt Aquitaine Laser) has been built in order to trigger the reaction of nuclear fusion which will help to conduct scientific experiments in astronomy and high field physics. PETAL is designed to deliver very powerful pulses (6 PW = $6*10^{15}$ W) but it still can't work at its full potential because due to these high powers, its optical components are sensitive to laser damage.

PETAL can deliver pulses whose temporal durations vary from 0,8 to 10 ps (1 ps = 10^{-12} s) and laser damage is sensitive to the pulse duration. Thus, the subject of this thesis is to study how the properties of laser damage are modified when the pulse duration changes. A laser bench called DERIC is used to conduct these studies in a similar temporal range (from 0,8 to 3,5 ps).

Laser damage can occur through three main forms : intrinsic damage, damage initiated on defects and damage growth. The goal of this thesis is to quantify how all of these forms of laser damage evolve when the pulse duration changes and to understand the physics of damage initiation and growth in such conditions.

Multi-level Feature Representation of FDG-PET Brain Images for Diagnosing Alzheimer's Disease

PAN Xiaoxi – GSM

Directeurs de thèse : Mouloud Adel

Using a single imaging modality to diagnose Alzheimer's Disease (AD) or Mild Cognitive Impairment (MCI) is a challenging task. FluoroDeoxyGlucose Positron Emission Tomography (FDG-PET) is an important and effective modality used for that purpose. We develop a novel method by using single modality but multi-level feature, which considers both region properties and connectivities between regions to classify AD or MCI from Normal Control (NC). First, three levels of features are extracted: statistical, connectivity and graph-based features. Then the connectivity features are decomposed into 3 different sets of features according to a proposed similarity-driven ranking method, which can not only reduce the feature dimension but also increase the classifier's diversity. Last, after feeding the 3 levels of features to different

classifiers, a new classifier selection strategy, maximum Mean squared Error (mMsE), is developed to select a pair of classifiers with high diversity. In order to do the majority voting, a decision-making scheme, a nested cross validation technique is applied to choose another classifier according to the accuracy. Experiments on Alzheimer's Disease Neuroimaging Initiative (ADNI) database show that the proposed method outperforms other FDG-PET-based classification algorithms, especially for classifying progressive MCI (pMCI) from stable MCI (sMCI).

Compressive Raman microspectroscopy

SCOTTE Camille – MOSAIC
Directeur de thèse : Hervé Rigneault

Conventional dispersive hyperspectral imaging requires spectral dispersion of light onto an array detector (e.g. CCD or EMCCD), for every image pixel. However, measuring a complete spectrum per spatial pixel leads to the generation of overwhelmingly large data sets and to lengthy acquisitions, especially in the case of inefficient processes such as spontaneous Raman scattering.

Actually, in many situations the aim of hyperspectral imaging is simply to quantify or classify the chemical species given their spectra. Then, acquiring complete spectra is inefficient since the information of interest (species proportions or class) is confined in a much lower dimensional basis than the spectral basis.

In compressive spectroscopy, chemometric analysis is integrated into the spectrometer hardware: the measurement is designed to directly probe quantities of interest (species proportions or class) instead of deducing them from complete hyper-spectral measurements. Typically, a programmable optical filter (e.g. DMD, digital micromirror device) displays optimized patterns to select wavelength combinations that efficiently estimate the quantities of interest. Corresponding photons are combined in a single-channel detector that replaces the detector array used in conventional hyperspectral imaging, with significant improvement in acquisition speed. In this contribution, we investigate the precision of proportion estimation with binary filtering of Raman spectrum mixture when the measurements are corrupted with Poisson photon noise. We experimentally validate the theoretical study on chemical solutions, and we image samples like latex beads or microcalcifications powders mimicking realistic biological samples. Comparison with conventional state-of-the-art spectrometers shows x10 to x100 reduced speeds.

Electromagnetic imaging techniques in complex media with random illuminations

UNGER Kevin – SEMO
Directeurs de thèse : Patrick Chaumet et Kamal Belkebir

L'imagerie électromagnétique consiste à caractériser spatialement un milieu en captant de la lumière. Le problème de la diffraction inverse consiste à restituer les propriétés

intrinsèques du milieu sondé à partir de sa signature électromagnétique. Un modèle physique est nécessaire pour décrire aussi précisément que possible l'interaction entre l'illumination et le milieu. Parmi les multiples interactions possibles, nous ne considérons que le phénomène de diffraction. Un échantillon est éclairé sous différentes illuminations, et pour chaque illumination, le champ électrique est mesuré à différentes positions d'observation. Dans la plupart des techniques d'inversion, l'amplitude, la phase et la polarisation du champ doivent être déterminées aux différentes positions d'observation. Aux fréquences optiques, la détermination de l'amplitude complexe du champ diffracté est faite à l'aide d'un montage interférométrique.

Je présente ici un algorithme itératif qui estime la carte de permittivité 3D d'un échantillon diélectrique à partir seulement de la mesure des intensités détectées. Dans un volume donné d'un milieu diélectrique linéaire isotrope, l'algorithme construit successivement des estimations de la permittivité de manière à minimiser l'erreur entre l'intensité mesurée expérimentalement et celle calculée par le modèle de diffraction.

Interaction Laser-UO_2 : Vers la simulation RIA à l'échelle du laboratoire

VIDAL Thibault – ILM

Directeurs de thèse : Laurent Gallais & Yves Pontillon

Le sujet de la thèse s'inscrit dans un cadre général d'étude, d'une part, des phénomènes d'interaction laser/matière et, d'autre part, du comportement des combustibles nucléaires irradiés dans des situations hypothétiques d'accident. Il s'agit d'utiliser les caractéristiques du chauffage au laser pour étudier le comportement de combustibles sous des charges thermiques représentatives des accidents du type RIA (Accidents de réactivité).

3 objectifs principaux seront donc appréhendés au cours de ce travail de thèse :

1. Etudier les interactions laser-UO2 en utilisant une simulation d'éléments finis pour définir des expériences et des conditions expérimentales adaptées aux besoins des études de combustibles (température, cinétique et gradients thermiques) et des contraintes expérimentales (source laser, géométrie des échantillons, disposition, diagnostic).

2. Mise en place d'un dispositif expérimental (Institut Fresnel) pour chauffer les combustibles nucléaires à l'aide d'un laser haute puissance avec des rampes de température jusqu'à plusieurs centaines de degrés par seconde, tout en utilisant des images haute résolution et thermographie infrarouge pour l'analyse.

3. Valider le fonctionnement d'un tel système dans un environnement nucléaire dans une installation capable d'étudier des combustibles réels ("Laboratoire Bernard François " au CEA Cadarache).

Depuis le mois de novembre 2017, avec l'arrivée du Laser, je travaille sur du Graphite, en attendant l'arrivée de l'UO2 à Fresnel. Mes expériences sur le graphite ont pour but de maitriser le matériel ainsi que l'expérience, mais aussi de définir les procédures de calibration appropriées des appareils de mesure utilisés. Tout cela afin de résoudre en avance de phase les problématiques anticipées sur l'expérience finale avec les pastilles de combustibles.

Ce travail a été financé par l'Ecole Centrale Marseille et le CEA de Cadarache

Doctorants de 2ème année Absents aux JDD

Minimising the risk associated with nanomaterials used in sunscreen at all product lifecycle stages-Nanoscreen

CATALANO Ricardo – CONCEPT / Interfast
Directeurs de thèse : Jérôme Labille et Myriam Zerrad

Among nanotechnology-based products, sunscreens are of emerging concern. Nanometric titanium dioxide (TiO2) UV-blockers are advantageous in terms of sun protection and aesthetics. However from a regulatory perspective, their fate and impact are still under consideration, due to their potential influence on both consumers and the environment. At present, many gaps remain in the scientific knowledge regarding the efficacy and safety of nanomaterials used in sunscreen. The present project aims to develop the eco-design of sunscreen by minimizing the risk at different stages of the product lifecycle, starting from its manufacture. This will be achieved by optimizing the properties of the UV blockers prior to their integration into the cosmetic formulation. The consequences of these characteristics on the overall risk of the final sunscreen product will be better evidenced throughout its lifecycle.

On the scale of nano-TiO2 filter, different coatings exist. The objective is to test and select different UV filters, in terms of both efficiency for filtering UV, of photo-passivation and of weatherability of the coating with respect to its environmental fate. During the aging of the product, the coating undergoes alteration likely or not to promote the dispersion of the nanoparticles in the environment. In addition, design a UV filter that does not fall within the category of nanomaterials, but preserves the sunscreen is also a track considered.

Etude des comportements électromagnétiques des matériaux en fonction de la température pour modéliser l'impact des échauffements générés par les frottements de l'air sur un aéronef lors d'un vol à vitesse élevée.

LETERTRE Thibaut – HIPE
Directeur de thèse : Pierre Sabouroux

En aéronautique, la variation en fonction de la température des caractéristiques électromagnétiques dans le domaine spectral des fréquences radar, de certains matériaux peut générer des problèmes important comme une modification du fonctionnement des antennes radar, ou encore une modification de la signature radar de l'aéronef, ce qui peut engendrer une dégradation importante des niveaux de furtivité nominaux d'avions d'arme. En effet, les matériaux utilisés dans la conception d'aéronefs discrets vis-à-vis des ondes électromagnétiques sont souvent soumis à des échauffements liés d'une part, aux frottements avec l'air dans le cadre de vols à hautes vitesses (par exemple pour les bords d'attaques des ailes) et d'autre part à des échauffement liés à la proximité de sources de chaleurs directes comme des tuyères de moteurs à réactions ou sorties d'échappements.

Les objectifs principaux de ce projet sont de concevoir un système large bande de caractérisations électromagnétiques de matériaux en fonction de la température et de proposer des modèles électromagnétiques relatifs à certains matériaux en incluant le paramètre d'intérêt, à savoir la température. Au-delà de ce travail de recherches de cette thèse, les résultats seront

transposables à d’autres cas soit à températures modérées comme des températures biologiques pour suivre des processus d’évolutions des permittivités de certains tissus en fonction d’une variation de température locale soit à températures plus élevées comme pour le suivi RFiD de dispositifs soumis à des températures élevées.

RESUMES DES 3ème ANNEES

Systèmes optiques dépolarisants

AILLOUD Quentin – CONCEPT
Directeurs de thèse : Myriam Zerrad et Claude Amra

De nombreuses applications spatiales nécessitent des détecteurs embarqués pour analyser les flux optiques provenant de la Terre ou de l'environnement. Ces flux sont collectés après avoir été diffusés et réfléchis par les différents éléments rencontrés, ce qui peut dans certains cas partiellement polariser la lumière étudiée. Cette dépolarisation n'est pas prédictible car elle dépend fortement des milieux traversés (nuages d'eau, de poussières, atmosphère…), alors qu'elle influe fortement sur la pertinence des grandeurs mesurées. L'une des méthodes proposées pour y remédier est de dépolariser la lumière incidente avant l'entrée dans le système optique. Néanmoins les systèmes utilisés à l'heure actuelle conduisent à des pertes conséquentes d'énergie ou à une division du faisceau considéré.

Nous proposons ici un nouveau type de composant capable de dépolariser la lumière tout en minimisant la perte d'énergie ; ce composant offre par ailleurs une bonne flexibilité spectrale, en termes de degrés de liberté. Il devrait ainsi permettre de conserver une précision optimale sur les instruments embarqués.

Fast stimulated Raman scattering with optical delay line

AUDIER Xavier – MOSAIC
Directeur de thèse : Hervé Rigneault

Stimulated Raman Scattering (SRS) is a non-linear spectroscopy scheme used to probe vibrational energy levels of molecules. Two pulsed lasers at ω_1 and ω_2 are focused on the sample. The sample is excited at the beating pulsation $\Omega = \omega_1 - \omega_2$ which typically falls into the vibrational levels of molecules ($1000 \rightarrow 3000\ cm^{-1}$). For instance, for $800nm$ and $1044nm$ lasers, the excited vibrational levels are those around $\Omega = (2\pi c)\ 2900\ cm^{-1}$. This is characteristic of CH2 and CH3 bonds, abundant in lipids and proteins. If these species are present in the focal spot, the transmission properties of our lasers are affected. By detecting this change in transmission over the field of view of a scanning microscope we can therefore realize an image with chemical sensitivity in a fully label-free way. The speed at which these spectral images can be acquired is usually limited by the time taken to switch from one vibrational frequency to the other. Combining Stimulated Raman Scattering in a spectral focusing configuration with an acousto-optic programmable dispersive filter working as a delay line, we achieve acquisition of spectrally resolved images at a frame rate of several images per second. This is orders of magnitudes faster than the traditional speed. This improvement allows for the recording of biologically relevant mechanisms, opening new applications for this technique.

Laser induced contamination on space optics

GEBRAYEL EL READIY Georges – ILM
Directeurs de thèse : Frank Wagner et Jean-Yves Natoli

Laser-induced contamination (LIC) of optical surfaces is a major obstacle for space-bound laser applications. Such hurdle is due to the formation of highly absorbing nanometric layers triggered by the interaction between high-power laser radiation and outgassed species from organic compounds.

In order to obtain space-like vacuum, a small vacuum chamber was designed and assembled to study LIC risk on optical payloads integrated on spaceflight missions in order to qualify optical components and organic materials designed for space applications. In this context, tests were performed with a nanosecond pulsed laser operating at a repetition rate of 10 Hz at 355 nm on fused silica substrates under toluene exposure with multiple laser irradiation. Specific experimental procedures are described in order to obtain repeatable and reproducible results. Several series of tests were performed to investigate the onset and further development phases of the induced deposit and the finally appearing contamination-induced laser-damage. In-situ (transmission and fluorescence) and ex-situ (profilometer, fluorescence, DIC microscopy) measurements were used for the characterizations.

Analyse de la diffusion lumineuse de pathologies cornéenne pour la quantification d'efficacité médicamenteuse

GIL Marion – DIMABIO
Directrices de thèse : Carole Deumié, Laure Siozade Lamoine
et Gaëlle Georges

Avec un coefficient de transmission de plus de 90% dans le visible, la fonction principale de la cornée est de laisser passer la lumière à l'intérieur de l'œil. Cette propriété unique d'un tissu dans le corps humain est liée à une absence de vascularisation et à une organisation très particulière du volume cornéen. Certaines pathologies, comme l'œdème cornéen, peuvent induire une perte de cette propriété. Cette diffusion croissante est attribuée au gonflement de la cornée liée à un disfonctionnement fonctionnel.

L'objectif de ce travail de thèse est de proposer des outils de diagnostic précoce des pathologies cornéennes, plus particulièrement de l'œdème.

Nous cherchons à développer une nouvelle méthode de diagnostic des modifications de l'état du tissu cornéen par une technique optique qui pourra être implanté à long terme in vivo et avec une sensibilité supérieure à celle des instruments existants (lampe à fente, pentacam, OCT…).

Ce projet nécessite de combiner une approche expérimentale utilisant les techniques disponibles au laboratoire (diffusomètre angulairement résolu et un système de tomographie par cohérence optique plein champ) et une approche théorique visant à comprendre comment les modifications structurelles à différentes échelles de tissus de la cornée influent sur les propriétés optiques mesurables par les techniques visées.

Photonic Lamb shift of a quantum emitter in the weak-coupling regime

LASSALLE Emmanuel – CLARTÉ

Directeurs de thèse : Thomas Durt et Brian Stout

It is well-known since the pionneer work of Purcell (1946) that the atomic properties such as its lifetime in the excited state, or its emission frequency, are not intrinsic properties of the atomic system, but instead characterize its coupling to the electromagnetic (EM) environment. Using an in-house code based on the generalized Mie theory, we investigate the modification of the emission frequency of a quantum emitter (called the photonic Lamb shift or frequency-shift) induced by nearby plasmonic nanoparticles, in the weak-coupling regime. Particularly, we show that this induced frequency-shift could be detected for a quantum emitter located in the nanogap of a gold dimer, because in this configuration the radiative decay of the quantum emitter dominates over the non-radiative decay. Moreover, we also use the resonant states of a general photonic resonator (also known as quasi-normal modes) to derive explicit formulas for the decay rate and frequency-shift of a quantum emitter clearly revealing the coupling to these modes, and providing a simple explanation of the spectral line shape of these physical quantities. This description also illustrates a fundamental distinction in the behaviors of closed (conservative) and open (dissipative) systems: the Lamb shift is bounded by the emission linewidth in closed systems while it overcomes this limit in open systems.

Détection et reconnaissance de cibles d'intérêt dans les images pour la mesure d'audience

MARTIN Benoit – GSM

Directeur de thèse : Salah Bourennane

Co-encadrants: Julien Marot (Institut Fresnel),

Régis LE BRAS et Alexandre JAUD (IntuiSense SAS)

La mesure d'audience est la récolte de données permettant de profiler une clientèle. Les données récoltées peuvent être, par exemple, le nombre de client, leur genre (homme/femme), leur âge ou encore leur temps de présence dans le lieu étudié. Un tel outil est pertinent, tant pour des études à but marketing que pour des études à but anthropologique.

Cette thèse, sous financement CIFRE, entre la société IntuiSense et l'Institut Fresnel a pour objectif le développement d'un outil de mesure d'audience embarqué sur des machines de Vending (type distributeurs de café) récoltant des données à l'aide d'une caméra.

Un tel outil doit être capable de détecter les personnes présentes dans son champ de vision, de les caractériser et de les suivre au cours de leurs potentiels mouvements tout respectant un fonctionnement en temps réel et en utilisant un minimum de ressources processeur.

Flexible multimodal miniaturized endoscope for non-linear imaging

MYTSKANIUK Vasyl – MOSAIC
Directeur de thèse : Hervé Rigneault

We have developed a non-linear flexible endoscope using a hollow-core double-clad silica fiber. This fiber transmits ultra-short pulses onto the sample without distortions, and back-collects 2-photon, Second Harmonic generation (SHG) and coherent anti-Stokes scatttering (CARS) signals generated by the sample. The device allows for a big field-of-view (FOV) imaging, which attends 500x500 microns with a speed of 8 images per second. This endoscope draws attention of clinical diagnostics specialistes from various domains (gastrology, pneumology, angiology).

The hollow-core fiber inserted in a piezo-electric tube allows for spiral scanning of the fiber's distal tip. At the fascet of this tip a 30 microns bead was inserted into the fiber core in order to focus tightly the laser light. 1-micrometer focal spot is then re-imaged by a distal optics of 2mm diameter. The total inner diameter of the probe equals only to 2.2mm. Hence being sufficiently thin to insert in a surgically prepared in advance little craniotoma in mouse scull, in order to observe hippocampus neural activity in vivo.

Etude des matériaux, composants et systèmes pour le domaine Térahertz par analogie aux méthodes optiques

POULIN Cyndie – ILM / CONCEPT
Directeurs de thèse : Hassan Akhouayri, Myriam Zerrad,
Meriam Triki (T-Waves Technologies)

L'objectif de ma thèse est d'étendre les modèles électromagnétiques existants pour les fréquences optiques vers le domaine des fréquences térahertz (THz), pour mieux comprendre les phénomènes physiques mis en jeu lors d'interaction onde-matière. Cette compréhension permettrait d'améliorer l'analyse des images THz acquises et de mieux définir les configurations des systèmes optiques utilisés. Ce travail est réalisé en comparant les résultats issus de la modélisation avec ceux provenant d'expériences menées par imagerie THz. Dans le future, la modélisation pourrait devenir un outil prédictif pour la caractérisation de matériaux dans le domaine THz.

Les ondes THz se situent entre l'infrarouge lointain et les micro-ondes dans le spectre électromagnétique allant de 0,01 mm à 3 mm (ou 100 GHz à 10 THz). Ces ondes bénéficient des avantages des ondes optiques et des micro-ondes dépendant des longueurs d'ondes utilisées. L'imagerie THz présente un fort potentiel pour la caractérisation de la matière, car ces ondes peuvent pénétrer beaucoup de matériaux qui sont opaques dans le visible et dans l'infrarouge. La détection de défauts, les délaminations, la présence d'humidité, etc…, sont un exemple des problématiques qui peuvent être investiguées grâce au rayonnement THz.

Dans un premier temps, j'ai pu simuler la réponse optique d'échantillons polymères plans homogènes et isotropes avec de bons accords entre le calcul et la mesure. Ces résultats ont permis de réaliser de premières modélisations d'images en adéquation avec l'imagerie THz. Par conséquent, l'étude est élargie aux matériaux anisotropes qui existent dans l'environnement

industriel actuel. On pourra également considérer des phénomènes optiques plus complexes sur échantillons cylindriques ou réseaux de diffraction.

Structural Organization of Actin Filaments probed by Polarized Fluorescence Microscopies

RIMOLI Caio – MOSAIC
Directeurs de thèse : Sophie Brasselet et Manos Mavrakis

Actin filaments are the major molecular target for studying animal cell morphology and motility due to their assembly versatility (single filaments, bundles, 2D networks and 3D gels) and to their ability to constitute mechanosensitive structures (sarcomeres, stress fibers and adherens junctions). However, many key questions on how cells assemble and organize actin filaments remain unclear, especially in real-time. Polarized fluorescence microscopies (PFM) are quantitative imaging techniques that are promising to fill up such gap, since it is possible to retrieve sub-diffraction orientation information from the fluorescent label in a noninvasive manner. However, most of PFM are diffraction limited techniques, thus vulnerable to different orientation misleading interpretation due to the ensemble averaging per pixel (e.g., overlapped structures, fluorophore wobbling, etc). To circumvent such limitations, we are developing a method called 4polar-dSTORM, which is a dSTORM imaging method projected on 4 polarization directions. This is a novel single-molecule-based PFM that will complement the ensemble data and provide moreover super resolution capabilities. With 4polar-dSTORM, it is possible to measure the fluorophore's orientation and wobbling independently of the complexity of the biological structure – and this for each individual fluorophore bound to actin filaments at the nanoscale. Our preliminary data on fixed patterned cells shows that 4polar-dSTORM is capable of retrieving such information, however it is sensitive to the background, to the excitation mode (normal incidence, tilted incidence or total internal reflection condition), and to the detection NA. We have shown that taking these parameters into account is crucial for unbiased determination of the orientation and wobbling parameters of single fluorophores. Our next step aim to use this method to quantify actin filament organization in different types of actin stress fibers under different biological conditions that are likely to affect actin filament structure.

Laser induced damage of fused silica optical components with centimeter sized beams

VEINHARD Matthieu – ILM / CEA
Directeurs de thèse : Jean-Yves Natoli et Laurent Lamaignère (CEA)

High energy laser systems are limited in their power output by the initiation and the growth of damage sites on the exit face of the fused silica optical components exposed to the highest laser energies at 3ω (351nm). Particularly, a thick (34mm) fused silica window is used to ensure the pressure difference between the laser chain and the experiment chamber. Because of its thickness, this component is the most critical as it is more likely to be subject to nonlinear

beam propagation. The aim of this thesis is therefore to study the initiation and the growth of laser-induced damage sites on fused silica optical components with a small-scale high energy laser system named MELBA. This laser bench is able to deliver a homogenous, 7mm, 4J laser beam at 3ω with a pulse duration that can be set between 1 and 12ns. This work will firstly study the initiation of laser damage sites on fused silica optics. A particular emphasis has been placed on the metrology of the laser beam, as nonlinear propagation is likely to increase the energy density on the exit face of the optical component. A dedicated imaging setup has therefore been employed to accurately measure the laser fluence. Finally, the growth of the initiated laser damage sites has been studied under different laser conditions (fluence, pulse duration). A statistical approach has been employed to study the growth behavior and probability of a large population of damage sites, and a deterministic approach has been employed to study the growth dynamic of damage sites that reach centimetric sizes.

Doctorants de 3ème année Absents aux JDD

Development of devices for measuring dielectric constants in wet materials to a better traceability of the measurement of humidity in solid

BEN AYOUB Mohamed Wajdi – HIPE
Directeur de thèse : Pierre Sabouroux

Several methods exist to measure moisture content in wet materials. Some of them are direct methods and some others are indirect methods. The first is used to extract the moisture directly from the solid substance but the second uses an intermediate which can be for example the dielectric complex permittivity $\varepsilon^* = \varepsilon' - j\varepsilon''$.

The object of this project is to study a new approach to measure moisture in solids following an indirect non-destructive method. It uses an approach via the electromagnetic measurement of the dielectric permittivity. This last depends on several factors: moisture, temperature and frequency. In our study we will work mainly with the third factor because the water in any solid can be characterized by its relaxation frequency. This frequency depends primarily on the degree of binding between amounts of free water and bounded water that interacts chemically or physically with the solid.

This type of measurement has existed since the 70s. Indeed, most existing systems operate at a fixed arbitrary frequency which can cause a measurement of the loss of sensitivity when it is removed from the relaxation frequency of water contained in the material. To find the best frequency with which we have a better sensitivity, two measurement cells are developed in CETIAT, the first one is a capacitive cell can be used in the range of frequencies between 1 MHz and 100 MHz and the second cell is a coaxial cell adapted to the characterization in the spectrum [50 MHz – 3.4 GHz]. To validate the measurement technique and also to further widen the measurement bandwidth we use EpsiMu® tool was developed at the Institut Fresnel.

The first step of the project is to validate the measurement techniques with a known permittivity material (liquids and solids) and then searching the frequency or the band of frequencies which allows us to find a better transfer function between the complex permittivity and humidity in solids and therefore we use this approach to generalize this relation permittivity - humidity to many types of solid materials.

Métrologie optique des pathologies cornéennes

HO WANG YIN Gaëlle – DIMABIO
Directeurs de thèse : Louis Hoffart et Carole Deumié

La cornée est un tissu transparent et avasculaire, organisée en cinq couches lui conférant des propriétés optiques particulières. Toute altération de sa structure à l'échelle nanométrique est responsable d'une modification de ses propriétés de diffusion. Le but de ce travail est de proposer des outils de diagnostic précoce des pathologies cornéennes avec une sensibilité supérieure à celle des instruments existants, en mettant à profit la méthodologie précédemment développée (étude de la diffusion tissulaire et tomographie à cohérence optique haute résolution).

Les mesures réalisées sur des tissus cornéens pathologiques, issus de pièces opératoires après greffe de cornée et de la banque de tissus de l'EFS de Marseille, seront confrontés à des modélisations réalisées en parallèle par une doctorante de formation physicienne Marion Gil dans le but d'approfondir les résultats clés obtenus sur une première série de pièces opératoires et greffons cornéens et d'ouvrir la voie de la détection précoce. Les premiers résultats obtenus ont montré que les instruments de mesure actuellement disponibles dans le service d'ophtalmologie de la Timone (OCT-SD du commerce, Pentacam®), ne permettaient pas d'imager correctement les pièces opératoires en cas d'altération structurelle trop importante, la face postérieure n'étant pas visible. Le Pentacam® permettant de mesurer la diffusion dans les 20 premiers degrés, ne pouvait mesurer précisément une cornée trop opaque. L'OCT haute résolution du laboratoire, nous a permis d'imager au micromètre près les pièces opératoires, tout en gardant à l'esprit qu'il s'agissait de coupes optiques et non histologiques. La diffusion angulaire a montré qu'il y avait une relation linéaire entre l'épaisseur et la diffusion et que toute altération structurelle de la cornée se traduisait par une augmentation de la diffusion. L'analyse de la diffusion angulaire plus particulièrement aux angles compris entre 20° et 70°, les 20 premiers degrés correspondant à des effets de surface, pourrait permettre de déterminer des signatures optiques spécifiques à chaque pathologie.

Ainsi, nos premiers résultats semblent prometteurs et une mesure angulaire de la lumière, couplée à une imagerie OCT haute résolution, paraît être un bon moyen de caractériser et de suivre les pathologies cornéennes. A terme, nous espérons créer un outil de diagnostic innovant dont la sensibilité permettra d'identifier de manière précoce des modifications des tissus cornéens liés à des pathologies (œdème, kératocône), d'évaluer l'efficacité de traitements médicamenteux ou encore de détecter très précocement un rejet de greffe.