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Proposal for ATHENA UMS – Spring School

Foundations, Applications, and Future Trends in Imaging Formation and Processing

Section 1 - Summary for ATHENA:

- **Organizers:** **Rafael Gregorio Mendes** and **Cécile Louchet**
- **Location:** Orléans, France (Physics-Chemistry Building, ICMN/CNRS, MACLE Platform)
- **Dates:** Week of May 19 to 23, 2025
- **Audience:** Master's, PhD, and Erasmus+ students (physical sciences, chemistry, materials)
- **Capacity:** Maximum 30 participants
- **Objectives:**
  - Master the fundamentals of imaging (optical, electronic, hyperspectral) and image processing.
  - Explore advanced techniques (tomography, AI) through lectures and practical sessions.
  - Develop practical skills using open-source tools (FIJI, Python, TOMVIZ).
- **Detailed Program Overview:** (*See appendix for full details*)

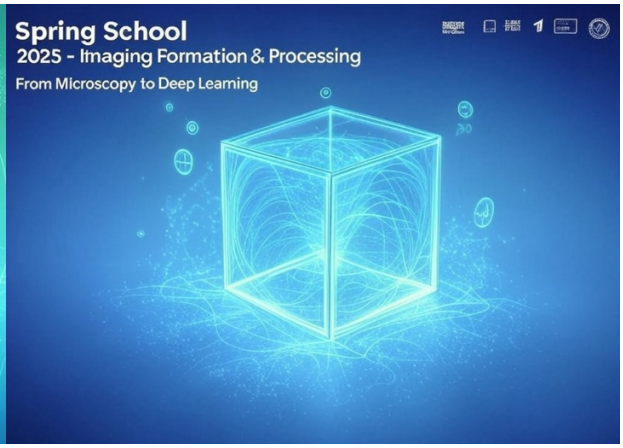
Day	Morning (9:00 AM - 12:00 PM)	Afternoon (2:00 PM - 5:00 PM)
Day 1: Foundations of Image Processing and Image Formation	**Lectures** (*Physics-Chemistry*): Introduction, Microscopy, Math/Filters	**Practical Session** (*Computer Room*): Filters/FFT on graphene images (FIJI, Python)
Day 2: Image Formation Techniques	**Lectures** (*ICMN/CNRS*): Optics, Electrons (TEM/SEM), Comparison	**Practical Session** (*MACLE + Computer Room*): TEM/SEM visit, TEM simulation of graphene
Day 3: Advanced Techniques and 3D Imaging	**Lectures** (*Physics-Chemistry*): Tomography intro, Simple practical, Seminar	**Lecture + Practical Session**: Electron tomography, TOMVIZ demo
Day 4: Introduction to Hyperspectral Imaging Techniques and Multimodal	**Lectures + Practical Session** (*Physics-Chemistry*): Multispectral, Multispectral practical	**Lectures + Seminars:** EDX/EELS, Hyperspectral, Multimodal
Day 5: Trends and Future Directions	**Lectures** (*Physics-Chemistry*): Deep Learning, AI Seminar	**Practical Session:** Escape Game, Group presentations

- **Modalities:**
  - Duration: 5 days, 6 hours/day (9:00 AM - 12:00 PM + 2:00 PM - 5:00 PM)
  - Assessment: Participation in practical sessions, escape game resolution, final submission.

- **Application:**
  - Deadline: **To be determined**
  - Contact: aide.minerve@univ-orleans.fr

Section 2: Visual Description

- **Title:** Poster Proposal for Spring School 2025
- **Description:**
    - Format: A4 vertical
    - Background: Gradient from deep blue (#1E3A8A) to turquoise (#06B6D4)
    - Central Illustration: Transparent 3D cube with light lines (tomography), subtle TEM microscope silhouette, turquoise sinusoidal waves (Fourier), graphene-like particles
    - Floating Icons:
        - "Fourier" (wave)
        - "TEM/SEM" (microscope)
        - "Tomography" (cube)
        - "AI" (neural network)
    - Title: "**Spring School 2025 – Imaging Formation & Processing**"
    - Subtitle: "*From Microscopy to Deep Learning*"
    - Bottom Text: "May 19-23, 2025 | Orléans, France | Univ. Orléans x Minerve x ATHENA | 5 ECTS"
    - Logos: Univ. Orléans + ATHENA (top right)
    - Visual Proposals:



Program proposed by Rafael Mendes and Cécile Louchet

Day 1: Foundations of Image Processing and Image Formation *(6h; at the Physics-Chemistry building)*

Morning: Lectures (3h)

1. **Introduction to the School and Goals**
    a. Introduce ourselves
    b. Briefly present the Spring School program to the students

2. **General introduction on microscopy techniques, basic physical concepts, and applications**
    a. Scale of things (depending on the scale of samples (e.g., macro, micro, nano, atomic…) and information required, different techniques need to be used)
    b. Basic physical concepts (e.g., electron, neutron, positron, electromagnetic spectrum (X-rays, UV-Vis, IR)
    c. Overview on types of microscopy/spectroscopy techniques (based on the physical concepts presented above) and the information that you can obtain
    d.

Break 15-20 minutes

3. **Mathematical Foundations of Image Processing**
    a. Basics of Fourier Transform and its relevance to images
    b. Frequency domain analysis
    c. Image Filtering
        - Types of filters: low-pass, high-pass, band-pass
        - Spatial vs. frequency domain filtering
        - Practical examples in 2D image processing

Lunch break (90 minutes)

Afternoon: Hands-On Session (3h)

- Implementing Filters and Fourier Transform (Give some graphene images to Cécile for demonstration and for the students to try) → We could use open-source software with built-in tools (e.g., FIJI, ImageJ, Digital Micrograph, etc….)

Break 15-20 minutes

- Using Python for filtering and FFT on sample images.

Day 2: Image Formation Techniques *(6h; at the at the Physics-Chemistry building and ICMN/CNRS)*

Morning: Lectures (3h) (at ICMN/CNRS)

1. **Image Formation Using Light**
    a. Optical microscopy: principles and limitations
    b. Instrumentation
    c. Fluorescence imaging and super-resolution techniques

Break 15-20 minutes

2. **Image Formation Using Electrons**
    a. Transmission electron microscopy (TEM)
    b. Scanning electron microscopy (SEM)

3. **Comparison Between Light and Electron Imaging**
    a. Advantages, challenges, and complementary nature of techniques

Lunch break (90 minutes)

Afternoon: Hands-On Session (at MACLE PLATFORM and computer room university)

-Visit TEM and SEM microscopes (divide students in 2 groups); total 90 minutes (each group 45 min. on each microscope) → bring simple sample for each microscope and show imaging modes to the students

-- Rafael asks Corinne Bouillet who could help with the students at the SEM –

Break 30 minutes (to move to the university computer room)

- Demonstration/Hands-on of TEM image simulation of graphene

Day 3: Advanced Techniques and 3D Imaging (6h; at the Physics-Chemistry building)

Morning: Lectures and seminars (3h)

1. **Introduction to Tomography**
    a. Introduction (60 minutes)
    b. Simple hands-on practical (60 minutes)

Break 15-20 minutes

2. **Seminar on tomography (45-60 minutes)**

Lunch break (90 minutes)

Afternoon: Lecture and Hands-On Session (3h)

1. **Rafael continues with electron tomography lecture**
    a. Introduction and instrumentation
    b. Tilt-series acquisition
    c. Reconstruction and segmentation

Break 15-20 minutes

2. **Hands-on demonstration on electron tomography workflow using software TOMVIZ**
    a. Bring a tilt series and do the process of image alignment, reconstruction, and segmentation together with the students

Day 4. Introduction to hyperspectral Imaging Techniques (to do firstly) and Multimodal *(6h; at the at the Physics-Chemistry building)*

Morning: Lectures (3h)

1. **Basis of multispectral imaging**

Break 15-20 minutes

2. **Hands-on multispectral imaging**

Lunch break (90 minutes)

Afternoon: Lectures and seminars (3h)

1. **Combining spectral and spatial information**
    a. Basis on Energy Dispersive X-ray Spectroscopy (EDX) and Electron Energy Loss Spectroscopy (EELS)

2. **Seminar 1 (60 minutes): on hyperspectral imaging; Rachid suggestion**

3. **Seminar 2 (60 minutes): multimodal imaging**

Day 5: Trends and Future Directions *(6h; at the at the Physics-Chemistry building)*

Morning: Lectures (3h)

1. **Lecture (120 minutes): Introduction to deep learning**

Break 15-20 minutes

2. **Seminar 2 (60 minutes): AI and machine learning in image processing in materials science/electron microscopy**

Lunch break (90 minutes)

Afternoon: Hands-On Session (3h)

"Escape game activity"

- **Students try to solve a problem proposed by us using the knowledge and tools provided throughout the school**
    - **Students need to solve the task in the minimum amount of time using the least number of resources → simulate a situation where the students would need to publish their data first**
- **Students present the results (2-3 slides, 5-10 minutes each group)**