EXPRESIONES DE INTERÉS – BECAS PREDOCTORALES LACAIXA-INPHINIT

POSITION

1) **New schemes in X-ray tomography for biological samples**

2) **AREA OF KNOWLEDGE: Life Science panel**

3) **GROUP OF DISCIPLINES: Human Biology. Microbiology. Molecular Biology, Genetics, Cell Biology. Genomics and Proteomics, Biochemistry**

4) **RESEARCH PROJECT / RESEARCH GROUP DESCRIPTION (MÁXIMO 2000 CARACTERES SIN ESPACIOS)**

X-ray tomography (XT) is an emerging microscopy technique for three-dimensional visualization of cryo-preserved , whole, unstained cells at a spatial resolution of 30 nm in the range of water window. It is, therefore, bridging the gap between the low-resolution visible light imaging techniques and the high resolution electron microscopy ones. In soft XT as in electron tomography (ET), a series of absorption contrast projections of the specimen are collected at different angles to finally compute the 3D absorption maps. In addition to the 3D structural information that can be obtained, the chemical sensitivity of the X-rays to the atomic elements of the sample can also be exploited to enhance visualization of these elements as well as to extract quantitative information from the data. However, absorption limits penetration distance in the sample. Other techniques, as X-ray phase-contrast tomography, are advantageous for biological XT because they allow deeper penetration into larger-scale structures such as tissue and organs but, in contrast, illuminating in the energy range known as hard X-rays. This phase contrast is produced integrating a phase ring in the back focal plane of the objective lens. By phase shifting the zeroth order diffraction beam, the recorded intensity of the interference between the primary wave and the diffracted wave can attain increased sensitivity particularly when applied to weak-absorbing objects.

Image processing for XT data should be rather different from the ET case, since in the case of both, absorption and phase-contrast XT techniques, the specific approximations related to ET may not apply. Moreover, images are, in general, a poorer approximation to ideal projection images than ET ones. Therefore, in this field the image processing challenge is the characterization of the microscope impulse response PSF and its appropriate incorporation into 3D reconstruction methods.

In the context of Soft X-ray Microscopy and synchrotrons, JMC was the scientist defending to the Scientific Advisory Committee(SAC) of the Spanish Synchrotron ALBA the proposal for the construction of a specific beam line for this type of Microscopy. JMC is currently member of the SAC of the European Synchrotron (ESRF), the Australian and the Netherlands Microscopy Centers as well as the Shanghai Protein Center.

5) **JOB POSITION DESCRIPTION (MÁXIMO 2000 CARACTERES SIN ESPACIOS)**

The position offered in this proposal will participate in the development of image formation modeling, specific reconstruction algorithms, workflows and computing protocols. As we are in close collaboration with Mistral microscope placed at Alba synchrotron (Barcelona), algorithms are oriented to Mistral microscope scheme and, at the same time, there is a direct access to experimental data that allows for the validation of novel algorithms.

Associated tasks:

1. Development of an image formation model for partially coherent optical systems. Depending of the matching of the numerical apertures of condenser and objective lens, the microscope response matches a partially coherent optical system, which has to be combined with the absorption contrast of the radiation-matter interaction.

2. **Parametrization of the optical system of Mistral microscope.** Experimental response of the microscope may differ from design parameters, leading to the need of a precise parametrization for properly applying the reconstruction algorithms.

3. **Reconstruction Worflow for X-ray tomography with partially coherent illumination**. Based on standard reconstruction algorithms, the development of adapted algorithms considering the partially coherent illumination will be implemented. In case a direct solution cannot be obtained, an iterative reconstruction algorithm will be used.

4. **Development of an image formation model for phase-contrast tomography using a Zernike phase ring.** The system response will be dependent on the Zernike ring radius, width and phase shift as well as the coherence conditions needed to obtain phase-contrast. If an analytical formation model cannot be obtained, a numerical process will be implemented.

5. **Reconstruction Worflow for X-ray tomography with Zernike phase-ring.** Development of specific reconstruction algorithms taking into account the partially coherent conditions of phase-contrast tomography as well as the Zernike ring parameters.

6. **Characterization of Zernike phase-ring parameters to optimize tomographic reconstructions in Mistral microscope.** From the analysis of the image formation model for phase-contrast and reconstruction workflow, the parameters of the Zernike ring that optimize the reconstruction results for the Mistral scheme will be identified.

GROUP LEADER

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