Research Centre for Greenhouse Gas Innovation

Lead institution: RCGI/USP	
Supervisor name: Rafael S. Gioria (POLI-USP)	**Department:** Mining and Petroleum Engineering Department – Polytechnic School – University of São Paulo
Recipient: https://sites.usp.br/rcgi/opportunities/ **Ref: 24PhD300 – Doctoral Scholarship** **Deadline for submission: August 30th, 2024**	**Type: PhD scholarship (1 position)** **Period: 40 hours/week** **Number of months: 48** **Intended beginning date: September, 2024**

Project title: (Portuguese and English)

Imagem quantitativa avançada de carbonatos do pré-sal (Caracterização de reservatórios sísmicos utilizando FWI)

Anisotropic ViscoElastic Numerical Inversion Research (AVENIR)

Research theme area: **(Portuguese and English)**

Inversão Sísmica, Propagação de Ondas, Método dos Elementos Finitos e Espectrais, Computação de Alto Desempenho, Dinâmica de Fluidos Computacional, Engenharias, Geofísica

Seismic inversion, Waves propagation, Finite and Spectral Elements methods, High-performance Computing, Computational Fluid Dynamics, Engineering, Geophysics

Abstract (Portuguese and English)

O candidato irá colaborar com os pesquisadores do projeto AVENIR fomentado pela Total Energies junto ao Research Centre for Gas Innovation da POLI-USP na Universidade de São Paulo. Resumo do programa e os projetos podem ser encontrados no site da RCGI (https://sites.usp.br/rcgi/). O objetivo geral do projeto de pesquisa é desenvolver algoritmos baseados em elementos finitos e diferenças finitas para resolver com eficiência e precisão problemas diretos e inversos associados à propagação de ondas viscoelásticas em meios anisotrópicos. Os códigos Devito (para diferenças finitas) e spyro (para elementos finitos) serão empregados como pontos de partida neste trabalho, de modo que os produtos do projeto de pesquisa se beneficiarão e herdarão o alto desempenho, portabilidade e flexibilidade dessas bibliotecas. Os códigos devem poder rodar em arquiteturas de CPU e GPGPU.

De forma mais específica, o(a) estudante bolsista desenvolverá a sua pesquisa em geração e adaptação de malhas para elementos finitos e espectrais e no desenvolvimento de algoritmos e estratégias para conciliar aplicações de modelo de ondas acústicas e modelo de ondas elásticas simultaneamente em regiões distintas no espaço. O desenvolvimento do solver será baseado no spyro (https://github.com/NDF-Poli-USP/spyro) que foi desenvolvido em cima do Firedrake (https://www.firedrakeproject.org/) e de geração/adaptação de malhas pode ser baseado no SeismicMesh (https://github.com/krober10nd/SeismicMesh).

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The candidate will collaborate with researchers from the project AVENIR promoted by Total Energies at the Research Centre for Gas Innovation of POLI-USP at the University of São Paulo. Summary of the program and projects can be found at the RCGI website (https://sites.usp.br/rcgi/).
The objective of the project AVENIR– Anisotropic ViscoElastic Seismic Imaging – is to build highly efficient, domain-specific language software tools to perform full waveform inversion (FWI) based on three-dimensional, tilted transverse isotropic (TTI) viscoelastic wave modelling. To achieve this goal, the team will first work on the construction of three-dimensional viscoelastic TTI kernels to be run efficiently in GPGPU hardware. Next, aspects related to accuracy and performance improvement will be tackled, namely the implementation of absorbing boundary conditions, correct representation of source injection and receivers, optimized spatial and time discretization schemes, and mimetic coupling between elastic and acoustic solvers. Next, the seismic imaging inverse problem will be dealt with by developing optimization algorithms, automating the calculation of gradients and devising robust techniques for multiparameter inversion and target oriented imaging. The project will be developed in three branches: Branch A will explore finite-differences discretization using the software Devito, Branch B will focus on high order finite-element discretization using the software spyro, and Branch C will be devoted to the development of robust elastic FWI algorithms. Branches A and B will be developed in two phases: Phase 1 will be dedicated to the construction of the numerical models for accurate and efficient forward propagation, and in Phase 2 the team will build FWI algorithms, incorporating the developments of Branch C into Devito and spyro. Key aspects that will permeate the entire development chain are abstraction, automatization, layering, flexibility, portability, performance, and integration.

More specifically, the PhD student will carry out his/her research in branch B. The PhD student will develop his/her research in mesh generation and adaptation for finite and spectral elements, and in the development of algorithms and strategies to match the applications of acoustic wave model and elastic wave model in distinct regions in space. The development of the solver will be based on spyro (https://github.com/NDF-Poli-USP/spyro) which is based on Firedrake (https://www.firedrakeproject.org/) and the mesh generation/adaptation can be based on SeismicMesh (https://github.com/krober10nd/SeismicMesh).

Description (Portuguese and English)

O candidato contribuirá alinhado aos principais objetivos do projeto:

1. Desenvolvimento de algoritmos de geração e adaptação de malhas para produzir discretização espacial otimizada para propagação de ondas elásticas e viscoelásticas anisotrópicas baseadas em elementos finitos;
2. Desenvolver estratégias de correspondência de interface para permitir o acoplamento com solucionadores acústicos (e consequentemente economizar tempo de computação na propagação através da camada de água).

The applicant will contribute in line with the main objectives of the project:

1. Development of mesh generation and adaptation algorithms to produce optimized spatial discretization for finite element-based anisotropic elastic and viscoelastic wave propagation;

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2. Develop interface matching strategies to allow the coupling with acoustic solvers (and consequently save computing time in the propagation through the water layer).

Requirements to fill the position. (Ex: specific experience, minimum or maximum years after concluding the course) (Portuguese and English)

Este projeto é adequado para um(a) candidato(a) altamente motivado(a) e requer habilidades de programação e conhecimentos de métodos numéricos. O(A) candidato(a) deve ter formação de nível superior em engenharia, computação, matemática, física ou geofísica. Conhecimento em inglês é necessário. Experiência na elaboração de métodos e ferramentas de computação de alto desempenho serão considerados diferenciais.

This project is suitable for a highly motivated candidate and requires programming skills and knowledge on numerical methods. The candidate must have a university degree in engineering, computing, mathematics, physics or geophysics. Knowledge of English is required. Experience in the development of either high-performance computing is a differential.

Funding Notes: Esta chamada oferece uma bolsas para esse projeto. A bolsa de doutorado será financiada pela FUSP – Fundação de Apoio à Universidade de São Paulo. A bolsa cobrirá uma bolsa de manutenção padrão de R$5.500,00 por mês.

This call offers one grant for this project. This PhD scholarship is funded by FUSP – Fundação de Apoio à Universidade de São Paulo. The scholarship will cover a standard maintenance stipend of R$5.500,00 (five thousand and five hundred Brazilian Reais) per month.

Work place: Fluids & Dynamics Research Group (https://ndf.poli.usp.br/ - Núcleo de Dinâmica e Fluidos) at Escola Politécnica de São Paulo (Polytechnic School of the University of São Paulo) Av. Prof. Mello Moraes, 2603 - São Paulo – SP, 05508-030

Documents/Information to be Sent:
Ref: 24PhD300

1) Access the link https://sites.usp.br/rcgi/opportunities/
2) Find the Position **Ref: 24PhD300**
3) Click on Application to apply

Deadline: August 30th, 2024

In case you have any question, please write to rcgi.opportunities@usp.br