SPIN MONITORING A RESTLESS EARTH

SPIN ESR 2.2: Understanding Earthquake-Induced Damage & Healing of Crustal Rocks

Host institution: University of Edinburgh, U.K

Supervisors:

Main supervisors: Dr. Mark Chapman & Prof. Andrew Curtis (University of Edinburgh, U.K.)
Co-supervisors: Dr. Yann Capdeville (University of Nantes, France)
Dr. Ernst Niederleithinger (B.A.M., Berlin, Germany)

Application deadline: April 1st, 2021, position remains open until filled
Earliest possible starting date: ?

General information

This PhD position is one of the 15 Early Stage Researcher (ESR) positions within the SPIN project (http://spin-itn.eu). SPIN is an Innovative Training Network (ITN) funded by the European Commission under the Horizon 2020 Marie Sklodowska-Curie Action (MSCA).

SPIN will focus on training 15 PhD candidates in emerging measurement technologies in seismology. We will research the design of monitoring systems for precursory changes in material properties, all while optimizing observation strategies. The unique interdisciplinary and inter-sectoral network will enable PhDs to gain international expertise at excellent research institutions, with a meaningful exposure of each PhD to other disciplines and sectors, thus going far beyond the education at a single PhD programme. For further information on the project, please consult our website at: http://spin-itn.eu.

Project Summary
Rocks and infrastructure such as bridges and dams are damaged by seismic waves from global earthquakes. They then heal over time, but we do not know how. You will investigate.

Project description
After an earthquake, seismic waves propagate throughout the Earth, and are measured on seismometers distributed around the globe. These waves temporarily deform rocks that they pass through, and recently we have observed that this appears to damage the rocks, which causes them to soften (deform more easily). These softened rocks can then be observed to 'heal', recovering their stiffness over timescales of minutes to years. Novel techniques from the field of seismic interferometry are revolutionising our ability to observe these dynamics, detecting and monitoring tiny changes in rock properties. We can now see that seismic waves from earthquakes occurring around the world create a constant state of flux in rocks near the Earth's surface: their properties are changing dynamically and constantly over all currently-measurable timescales. This observation requires that we now change the current geoscientific paradigm of a quasi-static solid Earth.

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Currently there is no consensus on what physical processes within the rocks cause damage and healing. Various models of the process have been proposed, but to-date we cannot discriminate between them. Indeed, we do not even know whether it is possible to discriminate between certain classes of theories since no experiment which might allow us to do so has been proposed. This is important from the point of view of material science and fundamental processes of matter, since without physical models we cannot understand the process or predict its effects. It is also important because if the process that reduces material stiffness also diminishes its strength, then damage from passing seismic waves from one earthquake may make the rock more susceptible to fracturing, potentially nucleating a second, triggered earthquake. If the damaged 'rock' is in fact the concrete of a bridge or other critical infrastructure, this would make the bridge increasingly susceptible to catastrophic failure – yet it may heal or recover its strength over time. We would therefore like to be able to discriminate between competing models of the processes of damage and healing in order to predict and understand behaviour in a variety of key materials.

In this project you will, in collaboration with your supervisors and other ESR's, design and carry out a suite of experiments both in the laboratory (in GFZ Potsdam, Germany) and in the field (in the United Kingdom), using seismometers and potentially other novel instruments. These experiments will help to discriminate between competing hypotheses for material damage and healing. You will use these observations to refine and further develop your own models of the physical process. You will implement these in computer codes that simulate seismic waves passing through the Earth and through built infrastructure, damaging the medium as they go. Collaborating with other PhD students you will use your models and codes to better understand phenomena such as earthquake or volcanic triggering, time-dependent infrastructure stress corrosion and failure, and a wide variety of other potential applications between which you and your supervisory team can choose.

Key Research Questions

1. What competing classes of hypotheses exist to explain observed damage and healing?
2. What are the implications of different models for forecasting future material properties?
3. How can we design experiments to discriminate between these models?
4. Should our new knowledge change the current paradigm of quasi-static rock properties?

Methods and Plan of Activities.

- Year 1: Learn about existing models for damage and healing, and identify their implications for the forecasting of future material properties. Write code that predicts seismic wave propagation including damage and healing of materials for each model. Design and carry out a laboratory experiment to discriminate between competing models. Write a first scientific paper on the results.
- Year 2: Collaborating with other ESR's from SPIN, design a field experiment to investigate whether the laboratory results extend to rocks in the real Earth. Acquire experimental data that allows different models to be compared. Analyse these to identify most likely physical processes, develop new models as needed, and write a second scientific paper.
- Year 3: Deploy new methods and models to a range of applications available through the SPIN network. Write papers as opportunities arise.

Training

You will receive training in all necessary modelling methods, and multidisciplinary training for your chosen experimental methods (e.g., remote sensing data of various kinds such as acoustic/seismic/radar data measured in a laboratory, or from the ground surface, air or satellite). You will be rooted in your supervisors' leading research groups on geophysical, experimental and mathematical methods, and from

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whom you will learn additional skills as needed for your project. You will receive support to attend national and international conferences and workshops to disseminate findings to the scientific community, and will learn to prepare and submit scientific papers to internationally peer-reviewed literature. You will benefit from collaborating within an international team of 15 ESR's across Europe within SPIN.

Required skills and experience

We welcome applications from candidates who fulfil the following criteria:

- A completed research-oriented university degree, such as a Master's degree or BSc Hons, in a relevant field (e.g. Geophysics, Physics, Applied Mathematics, or similar fields) The PhD enrolment requirements will depend on the hosting institute, please refer to the individual project descriptions and institute webpages.
- An outstanding academic track record
- An good command of English, both verbal and written
- Dedication and enthusiasm for research, combined with scientific curiosity, reliability and the capacity to teamwork in an interdisciplinary environment.
- We seek a mathematically able candidate who is interested in Earth Sciences
- Candidates must satisfy all entry requirements for the PhD programme at the University of Edinburg (https://www.ed.ac.uk/studying/postgraduate/degrees/index.php?r=site/view&edition=2021&id=69)

Please ensure that you fulfil the following **eligibility criteria** for ESR (Early Stage Researcher) positions in H2020 MSCA-ITNs, as ineligible candidates cannot be considered:
https://spin-itn.eu/recruitment/#eligibility-criteria

Application Procedure

The **application deadline** is 1.4.2021 Application evaluations will start immediately, and will continue until all positions are filled. We wish to reflect the diversity of society and we welcome applications from all qualified candidates regardless of personal background. The selection will be exclusively based on qualification without regard to gender identity, sexual orientation religion, national origin or age.

Applications must include:

- A cover letter in which you describe your motivation and qualifications for the position.
- A CV including relevant competences, skills and publication list, if applicable
- Copies of degree certificate(s) and transcripts of records for previous studies (Bachelor and/or Master). Please indicate expected date of graduation if your Master's degree is not completed
- Contact information of two references
- Completion of the SPIN application form: http://uhh.de/min-spin-apply with copy to: andrew.curtis@ed.ac.uk

Applications should be sent in **one single pdf file** with filename `SPIN_YourLastname_YourFirstname.pdf' to spin-applications.min@uni-hamburg.de

Data handling

By applying to a PhD position, you agree that all data concerning your application may be stored electronically and distributed among the supervisors involved in the selection procedure within the MSCA ITN SPIN. If you do not agree, your application can not be processed further, due to the project's centralised recruitment process. The data are used solely for the recruitment process and we do not share information about you with any third party.

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