



# USC University of Southern California

## GEOL 609, Seminar in Earthquake Physics

### Description

**Units:** 3

**Term-Day-Time:** Tuesday 11-12:15, Thursday 4-5:15

**Location:** ZHS 265 / zoom

**Instructor:** Yehuda Ben-Zion ([benzion@usc.edu](mailto:benzion@usc.edu))

**Office:** ZHS 109

**Office Hours:** open door, by appointment

### Prerequisite(s):

There are no formal prerequisites.

### Course Description

The course covers state-of-the-art research material on the physics governing earthquakes, faults plate-boundary regions, and related data sets and techniques. Topics include theoretical and observational results on crustal deformation, ruptures, earthquake source properties, imaging of fault zone and lithospheric structures, spatio-temporal seismicity patterns, seismic hazard assessments, applications of machine learning techniques and more. The seminar is aimed at graduate students of earth sciences, physics, and engineering interested in promising research directions in earthquake physics.

The format is two weekly meetings and the material will be covered via a blend of lectures by researchers and student presentations. One weekly meeting (Tue 11-12:15) will consist of a lecture by outside and in-house researchers. Speakers will include experts in various branches of earthquake science and will be available for additional discussions with students after the seminar. In the other weekly meeting (Thursday 4-5:15, room ZHS 265), students will review papers related to the previous presentation and the next one. Specific topics and speakers will be provided later. The class may also include a 0.5-day workshop on topics of interest to most students taking the class (e.g., analysis of continuous seismic waveforms, detection of small earthquakes, analysis of earthquake source properties, imaging crustal structures), and/or a 1-day field trip to look at the environment and internal structure of a large fault zone.

The grade is based 50% on a term paper, 40% on student presentations of papers focusing on critical analysis of conceptual issues and assignments in workshop (when included in the class), and 10% on student participation in seminars and field trip (when included in the class). The term paper could be on original research or review of relevant literature on a topic related to earthquake

physics, and will be presented by students in the last week of the class. Examples of possible term projects are given at the end of the syllabus.

### **Learning Objectives**

The basic goal of the class is to provide the students with a broad overview and examples of current problems in the physics of earthquakes and faults. By the end of the term, the student should be familiar with multiple current research topics, data sets, processing techniques, theoretical methods and state-of-the-art results on properties and dynamics of earthquakes and faults. Lecture topics and speakers will be different in future semesters.

### **General reading material for the class topics**

Aki, K., and Richards, P. G., *Quantitative Seismology* (second edition), University Science Books, 2002.

Turcotte, Donald L., *"Fractals and Chaos in Geology and Geophysics"*, Cambridge University Press, 1997.

Scholz, C. H., *The mechanics of earthquakes and faulting*, Cambridge, 2002.

Ben-Zion, Y., Appendix 2, Key Formulas in Earthquake Seismology, in *International Handbook of Earthquake and Engineering Seismology*, eds. W. HK Lee, H. Kanamori, P. C. Jennings, and C. Kisslinger, *Part B*, 1857-1875, Academic Press, 2003.

Kanamori, H., and E. E. Brodsky (2004), The physics of earthquakes, *Reports on Progress in Physics*, *67*, 1429 - 1496.

Ben-Zion, Y., Collective Behavior of Earthquakes and Faults: Continuum-Discrete Transitions, Evolutionary Changes and Corresponding Dynamic Regimes, *Rev. Geophysics*, **46**, RG4006, doi:10.1029/2008RG000260, 2008.

### **Term paper report and presentation**

Prepare a report on a topic related to Earthquake Physics. The report can be a literature review or new research involving calculations, data, or theoretical results done in consultation with the instructor. There are no page requirements for the reports; the emphasis is on quality rather than size.

Each student will lead a 30 minutes presentation on the topic of his/her term paper. A preliminary version of the final paper should be shown to the instructor for approval at least two weeks before. Students should prepare a handout to be distributed in the class at the time of the presentation.

### **Examples of Possible Topics:**

Energetics of faulting from seismic, lab or geological data

Automated detection of small events and development of earthquake catalogs

Nucleation, propagation and arrest of dynamic rupture.

High resolution imaging of fault zone structures.

Results related to modes of slip different than regular earthquakes (e.g. tremor, slow events).

Earthquake scaling laws: robustness, interpretation of variations.  
Summary of multi-disciplinary observations on a well-studied earthquake (e.g., Landers 1992, Izmit-Duzce, Turkey, 1999, Parkfield 2004, Ridgecrest 2019).  
Interaction and triggering of earthquakes. Tectonic scale migration of large earthquakes.  
Models and analyses of seismicity patterns and spatio-temporal complexity.  
Constraints on magnitude of crustal shear stress.  
Statistical mechanics of earthquakes, approach to criticality.  
Geodetic studies of earthquake deformation cycle; strain accumulation and post-seismic readjustments.  
Geological signatures of fault zone damage  
Roles of fluids in faulting.  
Earthquake prediction, physical basis, signals, important case histories, algorithms, robustness.  
Analysis of complex data; artifacts due to errors in data and model assumptions.  
Localization vs. distributed deformation in continental tectonics.  
Structure and phenomenology of large continental strike-slip fault systems (San Andreas fault, San Jacinto fault North Anatolian fault, Dead Sea transform).

### **Statement on Academic Conduct and Support Systems**

#### **Academic Conduct:**

Plagiarism – presenting someone else’s ideas as your own, either verbatim or recast in your own words – is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in *SCampus* in Part B, Section 11, “Behavior Violating University Standards” [policy.usc.edu/scampus-part-b](http://policy.usc.edu/scampus-part-b). Other forms of academic dishonesty are equally unacceptable. See additional information in *SCampus* and university policies on scientific misconduct, <http://policy.usc.edu/scientific-misconduct>.

#### **Support Systems:**

*Student Counseling Services (SCS) – (213) 740-7711 – 24/7 on call*

Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention. [engemannshc.usc.edu/counseling](http://engemannshc.usc.edu/counseling)

*National Suicide Prevention Lifeline – 1 (800) 273-8255*

Provides free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week. [www.suicidepreventionlifeline.org](http://www.suicidepreventionlifeline.org)

*Relationship and Sexual Violence Prevention Services (RSVP) – (213) 740-4900 – 24/7 on call*

Free and confidential therapy services, workshops, and training for situations related to gender-based harm. [engemannshc.usc.edu/rsvp](http://engemannshc.usc.edu/rsvp)

*Sexual Assault Resource Center*

For more information about how to get help or help a survivor, rights, reporting options, and additional resources, visit the website: [sarc.usc.edu](http://sarc.usc.edu)

*Office of Equity and Diversity (OED)/Title IX Compliance – (213) 740-5086*

Works with faculty, staff, visitors, applicants, and students around issues of protected class. [equity.usc.edu](http://equity.usc.edu)

*Bias Assessment Response and Support*

Incidents of bias, hate crimes and microaggressions need to be reported allowing for appropriate investigation and response. [studentaffairs.usc.edu/bias-assessment-response-support](http://studentaffairs.usc.edu/bias-assessment-response-support)

*The Office of Disability Services and Programs*

Provides certification for students with disabilities and helps arrange relevant accommodations. [dsp.usc.edu](http://dsp.usc.edu)

*Student Support and Advocacy – (213) 821-4710*

Assists students and families in resolving complex issues adversely affecting their success as a student EX: personal, financial, and academic. [studentaffairs.usc.edu/ssa](http://studentaffairs.usc.edu/ssa)

*Diversity at USC*

Information on events, programs and training, the Diversity Task Force (including representatives for each school), chronology, participation, and various resources for students. [diversity.usc.edu](http://diversity.usc.edu)

*USC Emergency Information*

Provides safety and other updates, including ways in which instruction will be continued if an officially declared emergency makes travel to campus infeasible. [emergency.usc.edu](http://emergency.usc.edu)

*USC Department of Public Safety – UPC: (213) 740-4321 – HSC: (323) 442-1000 – 24-hour emergency or to report a crime.*

Provides overall safety to USC community. [dps.usc.edu](http://dps.usc.edu)