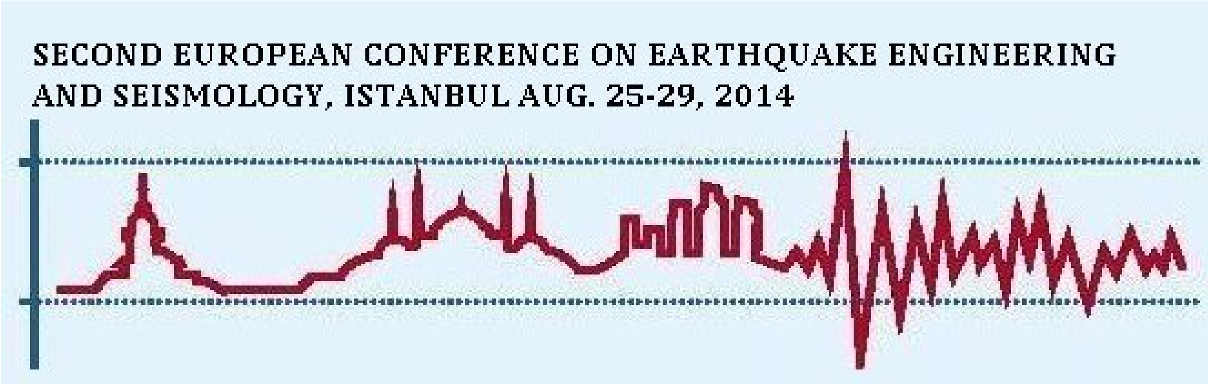

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DYNAMICS OF A TWO-ASPERITY FAULT SUBJECT TO STRESS PERTURBATIONS

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Michele Dragoni[1] and Antonello Piombo[2]

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Earthquakes are the result of the failure of a small number of fault asperities. Several recent large and medium-size earthquakes have been the result of the failure of two distinct asperities, such as the 1995 Kobe earthquake, the 2004 Parkfield earthquake and the 2010 Maule, Chile, earthquake.

Stress accumulation on each asperity, fault slip at asperities and stress transfers between asperities play a key role in fault dynamics. Therefore fault dynamics can be fruitfully investigated by means of discrete dynamical systems where the basic elements are asperities (e.g. Rice, 1993; Turcotte, 1997). The advantage is that the evolution of the system can be followed in the phase space, providing a deeper understanding of the behaviour of the system.

A fault made of two asperities can be modelled by a discrete system that was originally proposed by Nussbaum and Ruina (1987) and further investigated by Huang and Turcotte (1990), McCloskey and Bean (1992) and other authors. The fault is modelled as a dynamical system made of two elastically coupled slider blocks with different frictional strengths. The dynamics of the system has four different modes and produces a variety of behaviours: the asperities may slip one at a time, originating smaller earthquakes, or simultaneously, originating a larger earthquake. Dragoni and Santini (2012, 2014) solved analytically the equations of motion of the system and calculated the associated moment rates.

However any fault is subject to stress perturbations in connection with earthquakes generated by neighboring faults. The change in Coulomb stress (Stein, 1999) measures how much a fault is getting closer to or farther from the failure condition. Since the stress produced by a fault dislocation is strongly inhomogeneous, individual asperities belonging to a fault will be subject to different stress perturbations and to different changes in their Coulomb stresses.

We investigate the effects of stress perturbations on the dynamics of a fault containing two asperities. As a consequence of a stress transfer, the orbit of the system in the phase space is modified and the subsequent evolution may sensibly change. A stress perturbation not only changes the occurrence time of the following earthquake, but it may also change the slip amplitude and area, hence the seismic moment, of the earthquake, as well as the position of its hypocenter. The greatest changes take place when the simultaneous slip of asperities is involved. The change in the difference between the Coulomb stresses of the two asperities is a measure of how much the system gets closer to or farther from the condition for simultaneous slip.

As an application of the model, we consider the effect of the 1960 Great Chilean Earthquake on the two-asperity fault that produced the 2010 Maule earthquake (Delouis et al., 2010; Vigny et al., 2010)

[1] Professor, Dipartimento di Fisica e Astronomia, *Alma Mater Studiorum* Università di Bologna, michele.dragoni@unibo.it
[2] Assistant professor, Dipartimento di Fisica e Astronomia, *Alma Mater Studiorum* Università di Bologna, antonello.piombo@unibo.it

and calculate the change in the moment rate and in the total seismic moment. It results that, in the absence of the 1960 earthquake, the Maule earthquake would have occurred several decades later and would have involved a different sequence of modes, so that the moment rate function would have been very different, with a longer duration and a greater seismic moment.

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