Spontaneous earthquake nucleation on a rate- and state fault referring to the ’crack’ and ’asperity’

Yuta Mitsui[1]; Kazuro Hirahara[2]

[1] Dept. Geophys., Kyoto Univ.; [2] Geophysics, Grad. School of Sciences, Kyoto Univ.

The crack model, that is constructed of a inner region with a stress drop criterion and an outer region with a non-slip boundary condition, is the simplest and best-examined dynamic fault model. As the stress drop criteria, assumptions of a constant rupture velocity or a linear slip-weakening law are well used (*Madariaga[1976]*, *Day[1982]*). They need an a priori, initial condition for rupture start.

In contrast, by using a laboratory-derived rate- and state- friction law and one quasi-dynamic approximation (*Rice[1993]*), we can model a whole earthquake cycle: Stress accumulation, coseismic slip and post-seismic slip. The model enables us to investigate a spontaneous nucleation process, which is a given initial condition for rupture start in the classical crack model.

Specifically, following *Kato[2004]*, we assume a two-dimensional planar fault in a three-dimensional homogeneous elastic body and set a velocity-weakening region (with negative **’a-b’**) inside a velocity-strengthening region (with positive **’a-b’**). With this setting, the velocity-weakening region surrounded by the velocity-strengthening region seismically slips in a cyclic manner. Unlike the classical crack model, the outer velocity-strengthening region is slightly affected by the coseismic slip. Therefore, we call this model as a pseudo-crack model.

Results of our numerical experiments within a parameter range of **’a/b’** exceeding 0.5 are described below.

If the pseudo-crack is circular and homogeneous, the spontaneous nucleation starts near the center of it after quasi-static slip invasion from the velocity-strengthening region. It should be noted that the initial nucleus does not tend to lie at the true crack center but to encircle it. Such the feature resembles that of ”Asperity break model” (*Das and Kostrov[1983]*).

Further, whether we assume the aging state evolution law (*Dieterich[1979]*) or the slip law (*Ruina[1983]*) affects the nucleation process.

On an initial nucleation stage, when the crack center is still locked and the surroundings slip at velocity exceeding a fault loading rate by a factor of 10, the area of the locked zone does not have any parametric dependence on an aging law fault. However, on a slip law fault, they are inversely proportional to a parameter **’(L/b)$*$(G/S)’**, where **’G’** and **’S’** are rigidity and effective normal stress. Moreover, when **’(L/b)$*$(G/S)’** greatly exceeds 0.2, the residual locked center region apparently disappears.

When the nucleation process advances, on an aging law fault, high-speed slip starts from the residual locked center region. By contrast, on a slip law fault, high-speed slip starts from the narrow region within the surrounding nucleus. This nuclear localization on a slip fault is correspondent with a previous study using one-dimensional infinite fault model (*Ampuero and Rubin[2008]*). However, in the above case with **’(L/b)$*$(G/S)’** greatly exceeding 0.2, high-speed slip starts within as wide region as that on an aging fault.

Furthermore, during coseismic (slip velocity exceeding 1cm/s) slip, slip amount around the nucleous does not always take the largest value within the pseudo-crack. Though the nucleous in our model has an asperity-like feature on the initial stage as noted above, it does not necessarily correspond to a region with the maximum coseismic slip.

We will report more detailed results at the presentation.