Physics of earthquake triggering: effect of stress perturbation to slip acceleration

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Recent observation studies have revealed that the occurrence of tremors is sensitive to faint stress changes such as ocean tides. This might not be surprising in light of the low stress drop caused by tremors. Interestingly, however, ordinary earthquakes too may be sensitive to weak stress perturbations, although it is not so common as for tremors. Dynamic triggering should be the most prominent illustration of such sensitivity, but the occurrence of ordinary earthquakes could be also correlated to ocean tides, snowfalls, and rainfalls.

To understand such sensitivities to stress perturbation in a unified point of view, here we analyze the rupture nucleation process on a fault subject to weak periodic stress modulation. Assuming the rate- and state-dependent friction law with one state variable, we calculate the threshold amplitude above which the rupture initiation exhibits correlation with the perturbation phase. It is found that the crack-like nucleation is more sensitive to the perturbations than the patch-like nucleation. The estimated threshold amplitude for the crack-like nucleation is significantly lower than the tidal stress change. Time-to-failure for the both nucleation types in the presence of perturbation is estimated, and it is not significantly affected by the stress perturbation. We also discuss the optimum frequency at which the correlation is enhanced.

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