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Synchronization of Stick-Slip Oscillator by Periodic External Forces -Elastic and Viscoelastic Cases-

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In the last JpGu meeting, I reported the responses of stick-slip oscillator to periodic external forces. There, I examined the quasi-dynamic motion of a block connected with a spring pulling with a constant loading rate vpl, where the laboratory-derived rate- and state-friction law is working on the contact surface between the block and the underlying floor. I used frictional parameters a, b, L appropriate for velocity weakening and the spring constant k less than a critical stiffness kc to produce a repeating stick-slip motion of the block, which is a simple earthquake cycle model with a recurrences time. Then, I applied periodic external forces with several periods and observed clear m:n synchronization phenomena with synchronization frequency (period) widths, which is so called ‘Devil’ s Staircase’. Here, fe:fc (Tc:Te)=m:n (m and n are coprime integers) where fe and fc (Tc and Te) are frequencies (periods) of the external force and the simulated system, respectively.

This paper is a continuation of the previous one. The m:n synchronization is clear for the external force with the amplitude larger than 10 or 1 percent of stress drop during an earthquake cycle. At first, I supposed to use this synchronization for explaining the observed statistical significance of periodicity and seasonality of seismic activities. The stress changes of periodic daily and long-term tidal forces is an order of kPa. The amplitude of stress drop for usual earthquakes and slow slip events (SSEs) is an order of MPa and kPa. Then tidal forces can contribute to synchronization of SSEs, but not of usual earthquakes. But a simulation study shows a possible existence of long-term SSE with a larger stress drop of 0.1 MPa, which causes synchronization of large earthquakes such as those along the Nankai trough. The other extension is to investigate viscoelastic cases. The elastic spring is replaced by the standard linear solid, where the elastic spring with k1 and the Maxwell viscoelastic element (a spring with k2 is serially connected with a dash-pot of viscosity eta) are connected in parallel, and the relaxation time is tr=k2/eta. The change of relaxation time tr causes the recurrence times. And I discuss the synchronization in these viscoelastic cases, comparing with the elastic cases.

Keywords: Stick-Slip Oscillator, Synchronization, Rhythm, Earthquake Cycle Simulation , Periodic External Force, Elastic and Viscoelastic